SCIENCE ABSTRACTS.

Section A.—PHYSICS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

FEBRUARY 1915.

GENERAL PHYSICS.

149. *Plasticity*. **A. Pochettino.** (N. Cimento, 8. pp. 77–108, Aug., 1914.)—Liquefaction is usually associated with a discontinuity in the viscosity and in the elasticity. Is this discontinuity presented by substances which within a wide range of temperature are plastic, acting as solids to abrupt forces and as very viscous liquids to forces long applied? The author has studied ordinary black pitch, as regards (1) the coefficient of internal friction, (2) the Young's modulus, and (3) the Thomson and Tait coefficient of elastic restitution. *Internal friction.*—v. Obermayer (disc method) gives 126×10^6 to 5100×10^6 at 10° C.; Trouton and Andrews, at 15°, give $4{\cdot}7 \times 10^6$ to 10×10^6; the author used three methods: Segel's from 13° to 50°, which showed that the viscosity does not vary with changes in the speed of deformation, Stokes's from 34° to 80° (rate of descent of a heavy sphere, observed by means of X-rays), and Reiger and Glaser's (rate of flow in tubes) for higher temperatures. The results agree well; and the value of η falls from 235×10^8 at 9° C. to 119 at 99·9° C., without any discontinuity, though the first and the last portions of the curve of temperatures and logs. of η are practically straight lines, from 9° to about 30–32°, and from 72–75° to 99·9°. The latter might be interpreted as showing that a true liquefaction takes place at 72° to 75° C.; the former, 30° to 32° C. marks a characteristic change of state. *Elasticity.*—Acoustic methods are much preferable to static, but still pitch is too soft. The author obtained comparable results from the vibrations of tubes filled with pitch at different temperatures; the modulus falls from 720 at 9·8° C. to 330 at 32·3°, to 64 at 44·3°, and to 0 at 51·8°. *Restitution.*—The coefficient of elastic restitution falls continuously, at first slowly, then more and more rapidly, from 0·92 at 10° C. to 0·44 at 28·1°, 0·12 at 31° and 0·0 at 32°. Between 32° and 75° pitch is in a plastic state, neither properly solid nor liquid. It appears that there is then a relation $E = 3(1 - 2\mu)$ K between E the modulus of elasticity, $\mu =$ Poisson's coefficient, and K the modulus of compression; μ then varies rapidly with the temperature, while in ordinary solids it varies but little and the relation between E and K appears to be linear. A. D.

150. *Measurement of Strain in Glass.* **F. E. Wright.** (Washington Acad. Sci., J. 4. pp. 594–598, Dec. 19, 1914.)—Reviews previous work on the optical properties of strained glass, and describes a new method for the accurate and ready measurement of relative retardations of the light-waves after transmission through any particular part of a glass plate. In this method the plate is examined by strong monochromatic light (the green line 546 $\mu\mu$ of a mercury lamp viewed through Wratten and Wainwright filter No. 77 has been found suitable) between crossed nicols, the path difference of the emergent waves being measured by means of a special form of bi-quartz compensator. This compensator consists of two quartz plates and two quartz wedges cut parallel to the principal axis and mounted as in

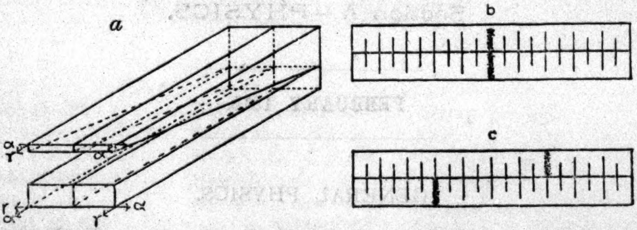


Fig. *a.* When viewed in the diagonal position under crossed nicols this wedge shows a dark transverse band of exact compensation as in Fig. *b.* The wedge is so ground that graduations on the upper surface of the compensator indicate directly the path differences in $\mu\mu$ for the wave-length of light employed. It will be seen from the Figs. that the compensator is so constructed that on the insertion of a bi-refracting plate in the diagonal position, the dark band in the one half moves to the right while in the second it moves to the left as shown in Fig. *c.* In this way the shift produced by a path difference of less that 1 $\mu\mu$ may readily be detected. The relation between the optical retardations thus measured and the corresponding elastic deformations of a given piece of glass may be deduced by direct measurements on the glass when subjected to a series of mechanical loads of known magnitudes. J. W. T. W.

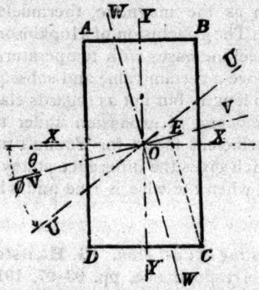
151. *Temperature Coefficient of Young's Modulus for Nickel.* **E. P. Harrison.** (Phys. Soc., Proc. 27. pp. 8–38, Dec. 15, 1914.)—Describes exceedingly careful experimental determinations of Young's modulus for nickel wire at temperatures ranging from 27° to 465° C. The wire used was stretched horizontally by means of a compression spring and heated electrically in a cylindrical chamber surrounded by a water-jacket. With this apparatus (of which a full description is given) it was found possible to plot a load-elongation curve for the wire at each temperature, using a series of loads the greatest of which was well within the elastic limit at the temperature employed. At each such temperature, provided "elastic after-effect" be absent or allowed for, these load-elongation graphs are found to be linear, showing (1) that no appreciable irreversible effects are produced on loading and then unloading, and (2) that the elastic temperature coefficient is the same for all the loads employed. The temperature of the wire was measured by finding its electrical resistance, and a constancy of within 0·3 deg. C. was found to be necessary in order to attain the accuracy aimed at. The

temperature coefficient of the resistance of the particular specimen of nickel used was carefully determined by subsidiary experiments. It is estimated that the temperature measurements are correct to about 4 deg. C. at the higher and lower temperatures, and to 8 deg. C. between 250° and 400° C. From a detailed mathematical investigation of the errors involved (other than those due to temperature changes) it is concluded that the probable error in the individual measurements of Young's modulus is about 2 %. It is found that up to about 300° C. the modulus for nickel diminishes slowly with rise of temperature, the relation being represented by the formula $E = E_0 (1 - 0{\cdot}0002860\theta - 0{\cdot}00000084650\theta^2)$, where $E_0 = 22{,}200$ kg./mm.^{2} for the specimen used. Above 325° C. the modulus is found to decrease rather more rapidly, reaching a minimum just below 400° C. It then remains nearly constant to 425° C., above which temperature a rapid decrease takes place. It is regarded by the author as likely that above 425° C. some structural change occurs in the metal, for at this temperature the wire is approaching the condition in which Hooke's law ceases to be true, small loads producing a permanent stretch which does not recover with time. It is to be noticed that the change in the temperature coefficient of the modulus occurs at the same temperature region as the magnetic, thermoelectric, resistance and expansion critical points. The conclusion of Hopkinson and Rogers that the "elastic after-effect" in steel increases with temperature, is found to be also true for nickel, loading above a certain value and subsequent unloading being followed by recovery as to length, but not as regards elasticity. The value of $d\alpha/dT$, where α is the coefficient of expansion under tension T, is deduced from the temperature coefficient found for Young's modulus, and hence a formula is determined which gives the difference at any temperature between the expansion due to heat when the wire is free and when it is subject to a load T. J. W. T. W.

152. *The Transverse Testing of Cast Iron.* **G. Hailstone.** (Iron and Steel Inst., J. 90. pp. 82–92; Correspondence, pp. 93–97, 1914. Engineering, 98. pp. 455–457, Oct. 9, 1914.)—The author describes a special machine which has been designed for making transverse tests on cast-iron bars of different dimensions. A series of tests have been made on a range of mixtures from weak to strong cast irons using test-bars 2 × 1 in. in section tested on 36-in. centres and 1-in. square bars tested on 12-in. centres. The results show that the ratio of the strengths is 1·153 for machined bars and 1·146 for bars tested with the skin on, instead of 1·333 as originally allowed for in the standard English specifications. The best standard test-bar, giving the most consistent and comparable results is the one cast to 2⅛ × 1⅛ in. in section and 42 in. in length and machined to 2 × 1 in. and tested on 36-in. centres. The rate of loading should not exceed 1 cwt. in 15 secs., this being a very convenient rate. F. C. A. H. L.

153. *Determination of Avogadro's Constant* N *from Measurements of the Brownian Movements of Small Oil Drops Suspended in Air.* **H. Fletcher.** (Phys. Rev. 4. 440–453, Nov., 1914.)—In a previous paper [Abs. 1652 (1911)] equations were developed which showed the effect of the so-called Brownian movements upon a spherical particle moving under the influence of a constant external force. In these formulæ there occurred a factor k which was a function of l/a, the exact dependence being unknown at the time the paper was written. For this reason the experimental work was directed toward determining Ne, which process did not involve k. Since that time Millikan, by a series of careful experiments, has determined the form of the function *k* [see Abs. 840 (1913)], and has thus made possible a fairly exact determination of N by the Brownian movement method applied to gases. The former equations have been modified so that the task of finding the Brownian movement is now much less laborious than before. The apparatus has also been improved, making it possible to obtain from 1000 to 6000 observations on a single particle. The results of the investigation show that the number of molecules in a gm.-mol. of air is $N = 60{\cdot}3 \times 10^{22} \pm 1{\cdot}2 \times 10^{22}$. This result only differs by 0·5% from the value obtained by Millikan, $N = 60{\cdot}62 \times 10^{22}$. A. W.

154. *Flexure of Eccentrically Loaded Columns.* (Engineering, 98. p. 760, Dec. 25, 1914.)—Shows the considerable errors which may be introduced into a calculation of stresses in beams bent in other than a principal plane, by the assumption, sometimes made, that the neutral axis will in such cases still remain perpendicular to the plane of the bending moment. Thus in the Fig., if ABCD be a section of a beam subjected to a bending moment applied in the plane of WOW, then the neutral axis is *not* the perpendicular VOV, but is really represented by UOU drawn at an angle ϕ such that $\tan\phi = I_1 \tan\theta / I_2$, where I_1 and I_2 denote the principal moments of inertia of the section. In the particular example worked out, viz., that of a rectangular section bent in such a way that the neutral axis is along one diagonal, the max. stress calculated on the erroneous assumption mentioned is 27% less than the true maximum. J. W. T. W.



155. *Unusual Solar Haloes seen in Kansas on February* 24, 1914. (Monthly Weather Rev. 42. pp. 271–272 and 273, May, 1914.)—Solar haloes of unusual appearance were observed in eastern, northern, and central Kansas on Feb. 24, 1914, from 9 a.m. to 10 a.m.; and sun dogs (parhelia) of considerably more than usual brilliancy were seen from 4 to 5.30 p.m. of the same day over the northern and central portions of the State. The haloes were observed at practically the same hour at all the reporting stations, which covered an area extending more than 250 miles west, and 75 miles south, of Topeka. The territory covered by the stations reporting either two or three brilliant sun dogs in the late afternoon was fully extended, and as in the case of the haloes, the sun dogs were seen at the same hour. The descriptions of the haloes seen at Topeka, Iola, and Garnett are given in the three following notes, without their accompanying diagrams. Noteworthy features are : (1) The overlapping of the 22° halo and its upper tangent arc as seen at Topeka, which seems to be new to science, though a similar overlapping has sometimes been reported for the upper bitangent arc and the circumzenithal arc of the 46° halo. (2) In the Iola observation the arcs of the 90° halo, with paranthelia. This is the rare "halo of Hevelius," which was also reported in connection with the remarkable haloes of Nov. 1 and 2, 1913. **S. D. Flora.** (Ibid. 42. p. 272, May, 1914.)—At Topeka the haloes consisted of the segments of four bright haloes and three sun dogs, or parhelia, in prismatic colours, and a white circle that extended entirely around the sky at the altitude of the sun. They were first noted at 9.30 a.m. and had mostly disappeared by 10 a.m. [90th mer. time]. Two very bright sun dogs about 5° long appeared one on each side of the sun at about 22° distance from it. The white circle extended horizontally through the sun dogs and the sun. It was sharply defined for about 100° on the outside of each sun dog, but could be scarcely distinguished between the sun dogs and the sun and in that part of the sky opposite the sun. The third sun dog appeared in this white circle about 46° north-east of the sun. Two intersecting haloes appeared 23° above the sun [see preceding note], and two more 46° above it. The halo nearest the sun was about 40° long, and if extended as a circle would have passed around the sun just outside the sun dogs. The second prismatic halo was convex to the sun and overlapped the first just above the sun. It was only 30° long, but was the brighter of the two, and this made the longer halo, the one concave to the sun, have at first sight the shape of a Cupid's bow. The segment of the halo turned convexly to the sun seemed to indicate that this halo if complete would have been elliptical. The two haloes 46° above the sun were arranged and coloured similarly to the ones at 23°, but were only about half as long. In each halo with spectrum colours the reddish tints were on the side nearest the sun. By 10 a.m. only the sun dogs were visible, and these disappeared by 11 a.m. The sky during this time was partly covered with a veil of cirro-stratus clouds so thin that they gave it a milky rather than a cloudy appearance except for just a few places where the clouds were plain. Most of the halo formation appeared where the clouds were thin. **H. K. Holcombe.** (Ibid. pp. 272–273, May, 1914.)—A complete circle of white light, two incomplete solar haloes, and four mock suns were observed from 9.15 a.m. to 11.25 a.m. [90th mer. time], Feb. 24, 1914, at Iola. Portions of the phenomenon were observed as early as 8.30 a.m., and gradually disappeared between 10.30 and 11.25 a.m. The large complete circle of white light parallel to the horizon at the altitude of the sun was the most conspicuous part of the phenomenon. There was an incomplete solar halo of 22° radius, and another very faint solar halo of 90° radius [the rare halo of Hevelius]. Where these haloes crossed the ring of white light, mock suns were produced. The inner halo and the two mock suns were well defined, and coloured with red on the inner side, blending with orange, yellow, green, blue, and vanishing with purple on the outer side. Nearer the zenith, another similarly coloured arc of a circle convex to the sun was observed. Where the faint halo of 90° radius intersected the ring of white light, the arcs and the outer two mock suns were of bright white light. During this time the sky was partly covered with a thin veil of cirrus and cirro-stratus clouds from the north. **D. D. Judy.** (Ibid. p. 273, May, 1914.)—On Feb. 24, 1914, beginning at 9.30 a.m. [90th mer. time] two solar haloes were seen, a small one around the sun coloured like the rainbow, that lasted but a short time, and a large white circle extending from the sun northward, with two sun dogs, one on each side of the sun. A. E.

156. *Distribution of Snowfall in Cyclones of the Eastern United States.* **C. F. Brooks.** (Monthly Weather Rev. 42. pp. 318–330, June, 1914.)—In the eastern states the greatest cyclonic rainfall generally occurs in the north-east quadrant of depressions. On account of the differences of temperature on the different sides, the distribution of snowfall does not follow the same rule. The greatest depth in this case is found to the north-west of the path of the cyclonic centre, in the region of cold north-east winds. Two intense snow-bearing depressions are described and illustrated by numerous maps. J. S. Di.

157. *Total Solar Eclipse. August* 21, 1914. **A. L. Cortie.** (Nature, 94. pp. 202–204, Oct. 22, 1914.)—Originally planned to make the observations of the eclipse at Kiev, in Russia, the party finally proceeded to Hernösand in Sweden. Three coronagraphs, of 20 ft., 30 in., and 12 in. focal length respectively were employed, and also a large Littrow spectrograph for recording the spectrum of the chromosphere and corona. Provision was made for impressing the spectrum plates with an artificial comparison spectrum for determination of wave-lengths. Successful pictures were obtained with all the instruments. The corona was of the windvane type, with equatorial extended streamers and delicate polar rays. With the spectrograph the spectrum of the corona was obtained showing faint continuous spectrum from λ4800 to λ6700, with several faint lines.

H. S. Jones and **C. R. Davidson.** (Nature, 94. pp. 230–231, Oct. 29, 1914.)—The observing party from the Greenwich Royal Observatory occupied a station near Minsk, in Russia. Instruments were provided for obtaining photographs of the corona, and also for the spectrum of the flash and corona. Although clouds were in the sky at the time, the eclipse was satisfactorily observed and the programme of observations completely carried out. The corona was of the intermediate type, with four streamers. Good photographs of the spectrum were obtained and will be described when the details have been measured.

B. Berloty. (Comptes Rendus, 159. pp. 611–615, Oct. 27, 1914.)—Observations of the second contact show that the actual epoch of totality occurred some 22 secs. earlier than had been predicted. Meteorological observations of temperature, humidity, pressure, actinometry were recorded, and also details of magnetic variations. The results are tabulated. C. P. B.

158. *Displacement of Spectrum Lines at Sun's Limb.* **J. Evershed** and **T. Royds.** (Kodaikanal Observatory, Bull. No. 39. Nature, 94. p. 263, Nov. 5, 1914. Abstract.)—The shifts of lines at the limb of the sun are considered to have no particular meaning when they are referred to the positions of the lines at the centre of the disc, for these latter have shifts peculiar to themselves. The new measures referred to a terrestrial standard source show no relation to the known shifts produced by pressure, and the absolute shifts do not increase with the wave-length. C. P. B.

159. *Rotation Periods of Saturn's Satellites.* **P. Lowell** and **V. Slipher.** (Lowell Observatory Bull. No. 64. Nature, 94. p. 239, Oct. 29, 1914. Abstract.)—From an investigation made in Dec., 1913, on the satellites Mimas and Enceladus, the authors conclude that their revolutions and axial rotations are synchronous. Observations of the albedo of the satellites are also discussed. C. P. B.

LIGHT.

160. *Apparatus for the Spectroscopic Synthesis of Colour.* **H. E. Ives** and **E. J. Brady.** (Frank. Inst., Journ. 178. pp. 89–96, July, 1914.)—The authors describe an apparatus for producing artificial light of any desired colour, which is similar in principle to that described in Abney's "Colour Measurement and Mixture." A spectrum is formed and a device is employed by which the intensity at any particular points can be diminished to a known extent before the rays are recombined. The most convenient method of producing this alteration in the character of the light is to introduce in the path of the spectrum a rotating sector disc, the sectors being specially shaped so as to obstruct any part of the spectrum to any desired amount. If a standard source is adopted we can thus produce any desired quality of light from it by cutting the sectors on the rotating disc in an appropriate manner. The standard source employed by the author is a 100-c.p. carbon filament glow-lamp accurately matched to the colour of the "4-watt-per-candle" lamps at the Bureau of Standards. Sectors have so far been prepared giving a reproduction of the light from the sun (black body at 5000° abs.) and the blue sky, and curves are presented comparing the radiation from such light with that of a 4-watt-per-candle lamp. It is suggested that this apparatus might be used to establish and preserve a standard of "white light." J. S. D.

161. *Visibility of Radiation.* **P. G. Nutting.** (Am. Illum. Engin. Soc., Trans. 9. 7. pp. 633–642, 1914.)—New visibility data are given for 21 subjects, together with their mean and a formula representing it. Determinations of the ratio of the international candle to the watt are given and also precise visibility data. The method of determining the visibility curves was similar to that used by Ives [Abs. 398 (1913)]. A wave-length spectroscope was fitted with a Whitman disc flicker photometer so that the pure spectral hue and a white surface illuminated by a standard lamp were viewed alternately. An acetylene standard lamp designed by Mees was employed. The average visibility curve agrees well with that of previous determinations. It is slightly more contracted than that obtained by Ives, the greatest difference from Ives's mean being on the blue side of the curve near the maximum. The mean wave-length of max. visibility is $0{\cdot}555\,\mu$ as against $0{\cdot}553\,\mu$ obtained by Ives. The theoretical formula which is found to agree well with the new data between wave-lengths $0{\cdot}48$ and $0{\cdot}65\,\mu$ is $V = V_m R^a e^{a(1-R)}$ in which $R = \lambda_{\text{max.}}/\lambda$, $a = 181$, and $\lambda_{\text{max.}} = 0{\cdot}555\,\mu$. The departure from the actual curve in the extreme red and violet is of slight consequence in computing the luminosity of sources on account of the relatively low visibility of radiation in those regions. [See also Abs. 1722 (1905).] A. W.

162. *Growth and Decay of Colour Sensations.* **M. Luckiesh.** (Phys. Rev. 4. pp. 1–11, July, 1914.)—Ives has shown that equality-of-brightness and flicker photometers do not lead to the same results with heterochromatic sources [see Abs. 1246 (1912)]; at low illuminations photometers of the flicker type show a *reversed* Purkinje-effect. This has been verified by the author. The flicker method is probably complicated by after-images, and by the different rates of growth and decay of the colour sensations; whereas in the case of equality-of-brightness photometers we have merely simultaneous contrast. The author describes a series of experiments on these points. An important result is that the brightness of a mixture of red and green light is practically the same whether the mixture is produced by superimposing the colours simultaneously or in succession (as in a revolving colour-disc); this supports the validity of Talbot's law for coloured lights. It appears that with both red and blue-green light there is an "over-shooting" of the sensation, but the effect is most pronounced with the red. As the illumination decreases the over-shooting becomes less marked. Other experiments show that the wave-form of the flicker may have a material effect on the results; a flickering red light on a green field does not produce the same impression on the eye as a blue-green flicker on a steady red background. These results suggest possible grounds of difference between flicker and equality-of-brightness photometers. The author, however, describes one final experiment which shows that in ordinary circumstances the two types of instrument should give similar results. By means of dyes two yellow lights, identical to the eye, were produced. One was a pure yellow, the other a mixture of red and green light. When the two colours were compared flicker and direct comparison methods gave results agreeing within 1 %. Similar results were reached with various "white" lights. J. S. D.

163. *Effect of Ultra-violet Radiation on the Eye.* **F. H. Verhoeff** and **L. Bell.** (Science, 40. pp. 452–455, Sept. 25, 1914. Elect. Rev. 75. p. 503, Oct. 9, 1914. Abstract.)—Many experiments have recently been undertaken regarding the effect of ultra-violet light on the eye, but there seems a lack of data on the *quantitative* relation between the radiation and its supposed pathological effects. Moreover, in experiments on solar radiation it is difficult to distinguish actinic from purely thermal effect. As a result of two years' quantitative researches the authors find that no artificial source of light used for illuminating purposes contains enough ultra-violet radiation to be of danger to the eye under practical conditions. In terms of energy 2×10^6 erg-secs. per cm.^{2} of the radiation emitted by the magnetite arc or quartz tube mercury-vapour lamp, would be required to produce conjunctivitis accompanied by stippling of the cornea; and about 2½ times this exposure is required to produce loss of corneal epithelium. Abiotic action for living tissues is confined to wave-lengths shorter than 305 $\mu\mu$. At least 18 times the above exposure to the quartz tube or magnetite arc is needed to penetrate to the back of the cornea. Abiotic actions produce effects quite distinct from those due to excessive thermal action; infra-red rays have no specific action distinct from thermic effect. Eclipse blindness, erythropsia, and glass-blowers' cataract do not appear to be due to ultra-violet radiation.

J. S. D.

164. *The Polychromide Process.* **A. Hamburger.** (Phot. J. 54. pp. 288–293; Discussion, pp. 293–294, Nov., 1914.)—Formulæ have been worked out for three sensitive emulsions of practically the same speed which can be made to respond to an arbitrary scheme for separation of colours into three more or less primary groups, now called "modified primary colours," in which the red-sensitiveness is permitted a certain amount of degradation by sensitiveness to the violet end of the spectrum, the yellow to be somewhat degraded by orange and the blue by green. With increased skill in the use of this arbitrary division it is possible to obtain three emulsions which are amenable to one exposure through one filter. In a special camera the ray of light passes through the lens and impinges upon a filter which is in a rigid frame. This filter is intentionally distorted on a carefully planned optical scheme. When the filter position is finally settled upon it is found that distortion always takes place in the same direction and at the same angles, therefore the filter is distorted in the opposite direction. The three images thus obtained being of identical size the prints register within as close a margin of accuracy as is required for any commercial purpose. The filter is at the same time a mirror, platinised by a special process, and the efficiency of the selection or separation apparatus is based upon the index of reflection of the mirror being exactly equal to the index of its refraction. This perfect equilibrium between refraction and reflection obviates the necessity for more than one filter. For work with varying means of illumination an extra filter, usually fitted to the lens hood, is employed in order to make the necessary compensation as between daylight and the various forms of artificial light, and the one set of plates is thus made to answer to all forms of illumination. They have been successful with electric arc-light, magnesium powders, the half-watt lamp, etc. In the preparation of the sensitive emulsions all methods of dye-bathing are discarded. The single filter is placed in front of the red-sensitive plate at the refraction back; no filter is placed on the reflection side of the camera where the other two emulsions are in position. These emulsions, the green-sensitive and the blue-sensitive, are placed film to film on their respective supports, one of celluloid the other of glass. The reversal of the celluloid film is not a serious matter, owing to its thinness. This expedient to secure contact is more advantageous than using two glass plates, because of the loss of sharpness which would follow in contact printing owing to the thickness of a glass plate. The images are reflected to these green- and blue-sensitive plates so that the three-colour images are obtained simultaneously through a single lens. The plates are so arranged that all three plates in the same set of batches have exactly the same speed. Over-exposure shows itself by halation from the whites and from sharp contrasts. It is, however, very easy to get correct exposure, and the process is eight times as fast as the screen plate, and affords more latitude in exposure.

From the yellow printing negative a black and white print is made on a paper, the equivalent of, and, with slight necessary qualifications similar to, ordinary bromide paper. The black and white silver print is bleached in chromic acid and thoroughly washed, the image being afterwards converted into a complex salt of silver, iodine, chromium, and mercury. The yellow develops in the process of washing, which requires 20 to 25 mins., the yellow becoming more and more intense until it may be regarded as complete when the whites all become clear. The yellow obtained has a tendency towards orange. The yellow print is dipped finally into a solution of gelatine, and is then ready to be superposed upon the red. The print obtained from the blue printing negative is treated on much the same lines. Instead of being on a rigid base, however, the print is on transfer paper, and, after fixing and washing, is laid down on a sheet of glass; after a few minutes' soaking in water at 100° F. the paper readily strips away. The blue is toned with ferricyanide of iron and potassium solution. No salt of silver by itself or in combination with other metals is found to give the desired red. From alizarine, however, a lake is evolved containing a salt of alizarine and silver.

The registration of the three constituent positives employed in this process is quite simple. The images are of exactly the same size, and the mere manipulation of the hand is sufficient to produce register. Artificial light is the best to print by. When mounted it is the custom to varnish the prints. During the *discussion* the **Author** stated that a matt surface could be used quite well for the finished result, and that there is no visible fading in prints made two years ago.

A. E. G.

165. *Photo-sculpturing.* **J. H. Smith.** (Am. Illum. Engin. Soc., Trans. 9. pp. 556-561, May, 1914.)—Illuminate the subject with light projected through a patterned screen negative; photograph the subject so illuminated. In the original position of the camera place a projection lantern projecting the photographic negative obtained; the patterned screen and this negative give two intersecting systems of light, the images produced by which coincide at some point on a screen; this point represents in space the original position of the corresponding point on the surface of the subject. From the original patterned screen and four to six photographic records the data requisite for reproduction in statuary can be compiled at any time. Illumination of the finished sculpture by means of projected coloured photographs gives an enhanced effect of likeness. A. D.

166. *Displacements of Spectrum Lines in Electric Arc.* **T. Royds.** (Kodaikanal Observatory, Bull. 40. Nature, 94. p. 291, Nov. 12, 1914. Abstract.)—An investigation was undertaken to determine the displacements of unsymmetrical lines under different conditions of the electric arc. The displacements near the positive pole were found to be about half those at the negative pole. A displacement in the same sense as that at the poles is produced at the centre of the arc by increasing the current or shortening the arc. Displacements still occur when the arc is operated *in vacuo*, but to a much smaller extent than in air at atmospheric pressure. C. P. B.

167. *Luminous Vapours distilled from the Arc.* **R. J. Strutt.** (Roy. Soc., Proc. 91. pp. 92-103, Dec. 1, 1914.)—A continuation of previous work [Abs. 1533 (1914)]. The conducting properties of a luminous jet of mercury vapour distilled from the arc *in vacuo* have been examined. The current depends on the shape and position of the kathode introduced into the jet, and is independent of the position of the anode. In the case where the anode is reached first by the stream of vapour, and a net electrode is used as kathode, all the positive ions may be taken out of the vapour that passes through the kathode. There is saturation of the current in the layer near the kathode. On the other hand, recombination proceeds in the rest of the space between the kathode and anode, for the electric force is concentrated near the kathode, and near the anode is not strong enough to take out all the negative ions. The luminosity of the jet is unaffected by the removal of negative ions at the anode, but is quenched by the removal of positive ions at the kathode. Although the removal of negative ions in the former case is not complete, it is considerable enough to show conclusively that the luminosity is independent of the number of negative ions present. Thus the luminosity is not due to recombination of ions. It seems necessary to assume that the luminous centres in the jet are survivors of those generated in the arc itself, in spite of the appreciable time (1/1000 sec.) necessary for the vapour to travel down the tube. We must suppose these centres to be positively charged to account for their removal at the kathode. Experimenting with other metals as well as mercury, it is found that the various lines of a spectrum are not, in all cases, equally extinguished when the jet of luminous vapour passes through a negatively electrified net. Thus the lines of the subordinate series of the sodium

spectrum apparently all lose intensity in the same ratio; but the D line of the principal series is much less affected. It is hence inferred that the luminous centres emitting the principal series are not the same as the luminous centres emitting the subordinate series. Analogous differences have been observed in the line spectra of Mg and Zn. The jets formed by As and Sb, which show band spectra consisting of large numbers of uniformly spaced bands, are not quenched by passing through a negatively electrified net. The luminous centres appear therefore to be uncharged in these cases. With the band spectrum of magnesium hydride it is otherwise. A. W.

168. *Enhanced Lines in Hydrogen Atmosphere.* **A. S. King.** (Astrophys. Journ. 40. pp. 213–218, Sept., 1914. Contribution from Mt. Wilson Solar Observatory, No. 85.)—Various workers have from time to time found the alterations of relative intensity of the spectrum lines of metals which are specially strengthened in the electric spark, and as in many cases these so-called enhanced lines appeared stronger when the discharge took place in an atmosphere of hydrogen, it has been sometimes stated that the presence of hydrogen is favourable to the presence of these lines. This may not be true, however, as the hydrogen materially modifies the character of the discharge conditions when the arc or spark is employed. To test the matter further the author obtained the electric-furnace spectra at various pressures with air and hydrogen, the metal under test being titanium. With a potential of 25 volts and current of 1500 amps., the tube was brought to a temperature of 2600° C. in about one minute. The results were quite definite in showing that no distinct effect on the intensity of the enhanced lines resulted from the use of hydrogen up to a pressure of 100 mm. At 200 mm. a weakening was perceptible, which became quite distinct at 400 mm. With regard to the effect of vapour-pressure, amounts varying from 0·01 gm. to 2 gm. produced no visible change in the relative intensities of arc and enhanced lines. Increasing the pressure, with temperature kept as nearly constant as possible, caused a progressive weakening of the Ti enhanced lines. C. P. B.

169. *Spectra of Magnesium, Calcium, and Sodium Vapours.* **J. Barnes.** (Astrophys. Journ. 39. pp. 370–372, May, 1914.)—Further experiments on the spectra of metallic vapours under the conditions given by an electrically heated furnace, the metals being vaporised *in vacuo*. In magnesium one of the chief features is this strength of the line λ4571, compared with its absence or weakness under other conditions. It is a well-marked sun-spot line. For calcium the chief affected line is 6573, which is noted by Hale and Adams to be one of the most strongly affected lines in the whole of the spot spectrum. The sodium D lines in the furnace spectrum are very much intensified, with wings very wide and clear, just as is noted in these lines in sun-spot spectra. These observations suggest that the experimental conditions reproduce very nearly the physical conditions of density, temperature, and excitation which may exist in sun-spot vapours. C. P. B.

170. *Ordinals or Atomic Numbers in Spectral Series Formulæ.* **A. van den Broek.** (Phil. Mag. 28. pp. 630–632, Oct., 1914.)—The author criticises J. R. Rydberg's suggested formula [Abs. 2012 (1914)] for the high-frequency lines determined by H. G. J. Moseley [Abs. 1249 (1914)], viz. $10^8/\lambda = \gamma = \gamma_0(N - C)^2$, where *a* is a constant, N are "ordinals" two units higher (for all elements except H) than the atomic numbers in the present periodic system, and C is a multiple of 3 for the *a*, and of 3·5 for the *b* series. The values for C seem disproved by the author's formula [Abs. 543

(1914)] for the γ-ray spectrum of radium B, and Moseley's series suggest quite other values. Numerous examples are quoted as tending to show that atomic numbers are to be preferred to "ordinals." G. W. de T.

171. *Enhanced Spectral Series and Atomic Models.* **A. W. Conway.** (Nature, 94. pp. 171–172, Oct. 15, 1914.)—A. Fowler has indicated [Abs. 1680 (1914)] an explanation on Bohr's theory of enhanced series in which the Rydberg constant is 4N instead of N. The author shows that his atomic model [Abs. 458 (1914)] would be capable of emitting similar series, the only assumption involved being that the electrons may be on the second nodal sphere of each mode. G. W. de T.

172. *Fluorescence of Iodine Vapour excited by Ultra-violet Light.* **J. C. McLennan.** (Roy. Soc., Proc. 91. pp. 23–29, Nov. 2, 1914.)—In a recent paper [Abs. 1284 (1913)] a new fluorescence spectrum of iodine vapour was described which could be stimulated by the light from the mercury arc. This fluorescence spectrum consists of a set of narrow bands extending from λ4600 to λ2100, the most intensely marked portion consisting of seven equally spaced bands between λ3315 and λ3175. It was found that the exciting light was of shorter wave-length than λ2893·7. The present paper contains the results of experiments made to determine the range of the exciting light, together with a statement of some points of interest in connection with the fluorescence spectrum which developed while these experiments were being made. It was shown that iodine vapour can be stimulated to the emission of a fluorescence spectrum excited by ultra-violet light at temperatures ranging from room temperature to at least as high as 1000° C. Iodine vapour ceases to be capable of emitting the resonance spectra discovered by Wood at some temperature below 326° C. The wave-lengths of the light which can stimulate the ultra-violet fluorescence spectrum of iodine vapour lie between λ2100 and a lower limit probably about λ1800. Resonance spectra cannot be obtained with iodine vapour when illuminated with light from the mercury arc of wave-length shorter than λ5460·74. Portions of the ultra-violet fluorescence spectrum of iodine vapour were obtained with iodoform and mercuric iodide at a temperature of about 326° C. Mercuric iodide and potassium iodide at a temperature of about 326° C. exhibit characteristic fluorescence spectra of their own when excited by light from the mercury arc. A. W.

173. *Mean Depth of Formation of X-rays in a Platinum Target.* **L. G. Davey.** (Phys. Rev. 4. pp. 217–221, Sept., 1914.)—W. R. Ham has shown that X-rays are formed, on the average, at a small distance below the surface of the antikathode, this distance being called the "mean depth" of formation of X-rays [Abs. 379 (1910)]. He also proved that this mean depth is directly proportional to the potential difference across the tube. The present paper contains an account of further experiments on this subject using a platinum target. For this metal, the mean depth of formation of X-rays in a tube of hardness H° Benoist is found to be, in cm., approximately 0·00004H. E. A. O.

174. *Soft Röntgen Radiation produced by Impact of Positive and Slow Kathode Rays.* **J. J. Thomson.** (Phys. Soc., Proc. 26. pp. 388–389; Discussion, p. 389, Aug., 1914. Phil. Mag. 28. pp. 620–625, Oct., 1914.)—The

production and investigation of a radiation intermediate between the ordinary X-rays and Schumann waves is discussed. This radiation is of great importance for the study of the constitution of the atom. It is pointed out that the work on X-rays has already demonstrated the existence of two separate rings of electrons in the atom, one within the other, these two rings being responsible for the K and L types of radiation. The L radiation is so much softer than the K that, if a third ring of electrons exists, the radiation from which is proportionately softer than that of the L type, this radiation would fall well within the gap already mentioned. A. B. W.

175. *Soft Röntgen Radiation produced by Impact of Positive and of Slow Kathode Rays.* **J. J. Thomson.** (Phys. Soc., Proc. 27. pp. 1–7, Dec. 15, 1914.)—Methods are described whereby a type of radiation intermediate between the Schumann (wave-length 9×10^{-6} cm.) and the Röntgen rays ($3{\cdot}6 \times 10^{-8}$ cm.) can be produced and studied. In the first method positive rays, after passing through a narrow slit, are allowed to fall on a Pt disc. The radiation emitted from this disc is examined in a side tube by a sensitive photographic method, using Schumann plates. The possibility that the strong photographic effects produced may be due to ultra-violet light or Röntgen rays from the discharge tube is eliminated by deflecting the beam falling on the Pt disc and showing that the photographic effect practically disappears. If, however, a strong electric field is applied to the rays emitted by the disc and passing down the side tube the photographic effect remains unaltered. This seems conclusive proof that the radiation which affects the plate is analogous to light or Röntgen radiations. This radiation is unable to penetrate even the thinnest obtainable films of collodion, mica, Al, or white fluorite. A similar type of radiation is produced by the impact of slow kathode rays. The penetrating power of the radiation produced in this case varies considerably with the energy of the kathode stream, but in every case is very small. The author notes that the great opacity of very thin films suggests that the frequency of the rays may be within the limits of those vibrations which, according to the usual theory of dispersion, are totally reflected by a medium. [See also preceding Abstract.] A. B. W.

176. *X-ray Spectrum of Nickel.* **W. F. Rawlinson.** (Phil. Mag. 28. pp. 274–277, Aug., 1914.)—A detailed investigation of the X-ray spectrum of Ni, with accurate measurements of the angles of reflection for rock-salt, heavy-spar, and potassium ferrocyanide, is described. The strong lines α and β are shown to be close doublets. Evidence is also obtained of several faint lines lying between them. The question as to how far the whole radiation from the Ni antikathode is concentrated in the two wave-lengths α and β has been investigated by an ionisation method. With a tube at 30,000 volts it was found that 79 per cent. of the radiation was absorbed exponentially with a value of $\mu/\rho = 55{\cdot}5$ in Al, the remaining 21% being absorbed approximately exponentially with a value of $\mu/\rho = 10{\cdot}36$. It was observed that μ/ρ for the hard radiation was about 3·25 for 42,000 volts, and 2·54 for 51,000 volts. A. B. W.

177. *Magnetic Spectrum of β-Rays excited in Metals by Soft X-rays.* **H. Robinson** and **W. F. Rawlinson.** (Phil. Mag. 28. pp. 277–281, Aug., 1914.)—The method consists in the analysis, by means of a magnetic field, of the groups of β-rays ejected by different metals when exposed to definite types of X-radiation, the source of radiation being a focus tube with

Ni antikathode [see preceding Abstract]. Iron and lead radiators were examined, the results being given in the following table :—

TABLE OF ENERGIES OF β-RAYS EXPELLED FROM IRON AND LEAD BY NICKEL X-RAYS.

Radiator.	$H\rho$ of expelled β-Rays.	Energy $\div 10^{11}e$.	Wave-length of Corresponding X-ray.
Iron (1)	267	6·28	$1·985 \times 10^{-8}$ cm.
(2)	334	9·79	1·273 „
(3)	364	11·61	1·074 „
Lead (1)	242	5·16	2·415 „
(2)	290	7·43	1·677 „

Faint bands have also been noticed with an Al radiator. The evidence obtained indicates the production of excited β-rays characteristic both of the antikathode and of the radiator itself. A. B. W.

178. *Radio-activity and Atomic Numbers.* **F. A. Lindemann.** (Nature, 93. p. 584, Aug. 6, 1914.)—Reference is made to a paper by van den Broek [Abs. 1687 (1914)], in which the importance of the charge on the nucleus in radio-active phenomena is pointed out. An explanation is offered in this communication. An interesting theoretical deduction of the law connecting periods of transformation and ranges, found empirically by Geiger, is also given. A. B. W.

179. *a-Ray Activities and Ranges in Actinium Series.* **H. N. McCoy** and **E. D. Leman.** (Phys. Rev. 4. pp. 409–419, Nov., 1914.)—In a previous paper [Abs. 1217 (1913)] the authors showed that the activity of each α-ray product of the Th series is proportional to the $\frac{2}{3}$rd power of its range. The experimental methods and results of an analogous study of the actinium series are now described. Radio-actinium and ActX are separated in a radio-actively pure form, and their ranges and periods determined. The results of the investigation are shown in the following table :—

	Periods.	Rays.	Ranges at 15° C. cm.
Actinium	?	—	—
Radio-actinium	18·88 days*	$\alpha + \beta$	4·40*
Actinium X..................	11·35 days*	α	4·40
Emanation	3·9 secs.	α	5·70
Actinium A	0·002 sec.	α	6·50
Actinium B..................	36 mins.	β	—
Actinium C	2·1 mins.	α	5·40
Actinium D..................	4·71 mins.	$\beta + \gamma$	—

* Values determined in present research.

Measurements on the change of α-activity of radio-actinium with time have shown that the α-activity of ActX + Em + A + C is 4·67 times that of the equilibrium amount of radio-actinium alone. This gives strong support to the view that the ionisation produced by an α-particle is proportional to the $\frac{2}{3}$ power of its range, and that in each atomic disintegration only one α-particle is expelled. A. B. W.

180. *Radium Constants on the International Standard.* **E. Rutherford.** (Phil. Mag. 28, pp. 320–327, Sept., 1914.)—Many radio-active measurements have been based on the radium standard known as the Rutherford and Boltwood standard. This was prepared eleven years ago and was assumed to contain 8·69 mgm. $RaBr_2$. On the new International standard its value has been found to be 8·51 mgm. and the author has calculated the more important constants in terms of the International standard. The results are given in the following table :—

Original Paper.	Quantity.	Rutherford and Boltwood Standard.	International Radium Standard.
Rutherford and Boltwood, Abs. 1574 (1906); Boltwood, Abs. 1100 (1908).	Amount of Ra in equilibrium with 1 gm. of Ur.	$3{\cdot}4 \times 10^{-7}$ gm. Ra	$3{\cdot}23 \times 10^{-7}$ gm. Ra
Boltwood and Rutherford, Abs. 170 (1912).	Production of He per gm. of Ra per year.	156 $mm.^3$	164 $mm.^3$
	Calculated value.	155 $mm.^3$	163 $mm.^3$
Rutherford and H. Robinson, Abs. 820 (1913).	Total heating effect of 1 gm. of Ra and its products in equilibrium with it.	—	134·7 gm.-cals./hour
	Radium alone	—	25·1 „
	Emanation „	—	28·6 „
	Radium A „	—	30·5 „
	Radium B } Radium C } „	—	50·5 „
Rutherford, Abs. 1798 (1908).	Volume of the emanation from 1 gm. of Ra in equilibrium.	0·60 $mm.^3$	0·63 $mm.^3$
	Calculated value.	0·59 $mm.^3$	0·62 $mm.^3$
Rutherford and Geiger, Abs. 1627 (1908).	Number of α-particles expelled per sec. per gm. of Ra itself.	$3{\cdot}4 \times 10^{10}$	$3{\cdot}57 \times 10^{10}$
	Number per sec. from 1 gm. of Ra in equilibrium.	$13{\cdot}6 \times 10^{10}$	$14{\cdot}3 \times 10^{10}$
Rutherford and Geiger, Abs. 1628 (1908).	Total charge carried by the α-particles per sec. from 1 gm. of Ra itself and from each of its products in equilibrium with it.	31·6 e.s. units $1{\cdot}05 \times 10^{-9}$ e.m. unit	33·2 e.s. units $1{\cdot}11 \times 10^{-9}$ e.m. unit
Geiger, Abs. 1547 (1909).	Total current due to α-rays from 1 curie of emanation ;		
	(1) by itself ;	$2{\cdot}75 \times 10^6$ e.s. units	$2{\cdot}89 \times 10^6$ e.s. units
	(2) with its α-ray products.	$9{\cdot}46 \times 10^6$ e.s. units	$9{\cdot}94 \times 10^6$ „
H. Moseley, Abs. 84 (1913).	Total charge carried by the β-particles emitted per sec. by RaB or RaC in equilibrium with 1 gm. of Ra.	17·4 e.s. units	18·3 e.s. units
	Calculated half-value period of transformation of Ra.	1780 years	1690 years

A. B. W.

181. *Passage of α-Particles through Photographic Films.* **H. P. Walmsley** and **W. Makower.** (Phys. Soc., Proc. 26. pp. 261–263, June, 1914.)—Microphotographs of the trails of α-particles projected tangentially to a photographic film have been obtained. The trails obtained in this way show a remarkable similarity to those obtained by C. T. Wilson in the case of the passage of α-particles through gases. The method described possesses the great advantage of simplicity and may prove of use in studying the scattering of α-particles, produced by heavy substances such as silver. A. B. W.

182. *Spectrum of β-Rays excited by γ-Rays.* **E. Rutherford, H. Robinson, and W. F. Rawlinson.** (Phil. Mag. 28. pp. 281–286, Aug., 1914.)—In a previous paper [Abs. 251 (1914)] Rutherford and Robinson have analysed the magnetic spectra of the β-rays of both RaB and RaC, and have measured the velocities and energies of a large number of groups from each element. Experiments are now described in which an accurate determination of the distribution of velocities of β-rays excited by γ-rays of RaB and RaC is made; the object of the experiments being to trace the connection of these excited β-rays with the primary rays emitted by the radio-active substance. The apparatus used is that described in the paper mentioned above. The following table shows clearly that the velocities of the two types of β-rays are the same in each case.

TABLE OF β-RAYS EXCITED BY LEAD.

Hρ of excited β-Ray.	Intensity.	Hρ of Primary.	Intensity.
3610	*f.*		
3250	*f.*		
2990	*s.*		
2735	*m.f.*		
2225	*m.*	2235	*s.*
2130	*f.*	2140	*f.*
2000	*f.*	1990	*m.s.*
1935	*v.s.*	1925	*v.s.*
1825	*m.f.*	1815	*m.*
1750	*m.f.*	1752	*m.s.*
1670	*v.s.*	1660	*v.s.*
1560	*f.*		
1400	*s.*	1392	*v.s.*
1240	*m.*		
1150	*m.f.*		
1080	*m.*		
1010	*m.s.*		
950	*s.*	950–914 (group)	*m.*
870	*v.s.*		
800	*s.*	798	*m.s.*

[*v.s.* = very strong; *s.* = strong; *m.s.* = moderately strong; *m* = moderate intensity; *m.f.* = medium faint; *f.* = faint.]

Further experiments were made, using screens of Al, Ag, Au, and Pb, to determine whether the velocity of the excited β-ray depends on the material through which the γ-rays pass. A. B. W.

183. *Number of Ions produced by the β- and γ-Radiations from Radium.* **H. G. J. Moseley and H. Robinson.** (Phil. Mag. 28. pp. 327–337, Sept., 1914.)—The method adopted was to measure the ionisation at different distances surrounding a known quantity of active material, using a small chamber with walls and framework so light that they do not affect the radiation. One gm. of Ra then produces in all, $N = \int_0^\infty 4\pi r^2 n\,dr$ pairs of ions per sec.; where n, the ionisation per cm.^{3} per gm. is a function of r. In the case of β-radiation

the value of this function can be found experimentally for all distances for which n remains appreciable. The effect of the γ-radiation is spread over too large a volume for this to be possible. The penetrating part of the γ-radiation, however, carries very much more energy than do the softer types, and is absorbed according to an exponential law. In this case therefore $n = ke^{-\mu r}/r^2$, and $N = \int_0^\infty 4\pi ke^{-\mu r}/dr = 4\pi k/\mu$. By means of a magnetic field the authors separated out the effects of the β- and γ-radiations, and by suitable means also separated out the effects due to RaB and RaC. The results are given in the following table :—

	N.	Heating Effect gm.-cals. per hour.	Average Energy emitted per Atom.
γ-radiation from RaC.........	$1·134 \times 10^{15}$	5·96 calc. 6·4 observed	$1·94 \times 10^{-6}$ erg
γ-radiation from RaB.........	$0·084 \times 10^{15}$	0·44 calc.	$0·14 \times 10^{-6}$
β-radiation from RaC	$0·64 \times 10^{15}$	3·35 calc.	$1·09 \times 10^{-6}$
β-radiation from RaB	$0·325 \times 10^{15}$	1·71 calc.	$0·55 \times 10^{-6}$
Total β- and γ-radiation from RaC	$1·774 \times 10^{15}$	9·3 calc.	$3·02 \times 10^{-6}$
Total β- and γ-radiation from RaB	$0·41 \times 10^{15}$	2·15 calc.	$0·70 \times 10^{-6}$

A. B. W.

184. *Connection between the β- and γ-Ray Spectra.* **E. Rutherford.** (Phil. Mag. 28. pp. 305–319, Sept., 1914.)—It was initially supposed that a large fraction of the β-radiation from substances like RaB and RaC appears in the form of homogeneous groups. Chadwick [Abs. 1426 (1914)] has shown, however, that their magnetic spectrum is continuous with a superimposed line spectrum corresponding to groups of rays expelled at definite speeds. The author explains this as follows: Suppose—as seems probable—that the disintegration of an atom leads to the expulsion of a high-speed β-particle from or near the nucleus. This β-particle in passing through the outer distribution of electrons will, on the average, suffer several collisions of an ordinary type with the electrons, and will share its energy with them. As a statistical result of a large number of atoms, the velocity of the escaping β-particles will, on the average, be continuously distributed within certain limits of velocity. This would give rise to the continuous spectrum of β-rays typical of RaE. Next suppose that there are certain well-defined regions in the electronic distribution which can be set into definite vibration by the escaping β-particle. These regions are to be identified as containing the particular structures which give rise to the "characteristic" γ-radiations from the atom. If some of the β-particles in escaping from the atom pass through one or more of these regions, they give rise to a line spectrum of γ-rays and at the same time to one or more groups of β-rays of definite speed. Thus the primary effect in the atom is the excitation of γ-rays by the escape of the β-particle from the nucleus. The appearance of groups of homogeneous β-rays is a secondary effect due to the partial conversion of the γ-rays into β-rays in their passage through the radio-active atom. The author

next considers the energy transformations involved in the above, using the ideas of Planck's quanta. The calculations give support to the theory and interesting connections between the β- and γ-radiations of the various products are indicated. **A. B. W.**

185. *Spectrum of Penetrating γ-Rays from Radium B and Radium C.* **E. Rutherford and E. N. da C. Andrade.** (Phil. Mag. 28. pp. 263–278, Aug., 1914.)—In a previous paper [Abs. 1548 (1914)] the authors have given the results of an examination of the wave-lengths of the soft γ-rays from RaB, for angles of reflection from rock-salt between 8° and 16°. Now an account is given of further experiments to determine the γ-ray spectra of the very penetrating rays from RaB and RaC. In order to determine the wave-length of penetrating rays of very high frequency, the authors have had recourse to a new method which depends on the measurement of absorption, as well as of reflection lines. The measurements were made (1) by the reflection method already described (*loc. cit.*); (2) by a transmission method. The latter method was found to be most satisfactory for the difficult nature of the measurements involved. For details of this very interesting method reference must be made to the original paper. The following table shows that the results obtained by the two methods are in good agreement :—

PENETRATING γ-RAYS FROM RADIUM B AND RADIUM C.

Transmission Method.		Reflection Method.	Wave-length.
Absorption.	Reflection.		
42′	43′	44′	$0{\cdot}71 \times 10^{-9}$ cm.
1° 0′	1° 0′	1° 0′	0·99
1° 10′	1° 10′	1° 11′	1·15
1° 24′	1° 25′	1° 24′	1·37
* { 1° 37′	{ 1° 36′	{ 1° 37′	{ 1·59
1° 44′	1° 44′	1° 44′	1·69
	2° 0′	2° 0′	1·96
2° 20′	2° 20′		2·29
		2° 28′	2·42
		2° 40′	2·62
	3° 0′	3° 0′	2·96
3° 18′†		3° 18′†	3·24
		4° 0′†	3·93
		4° 22′	4·28

* Possibly one broad line, although evidence is in favour of its double nature.
† Possibly second order.

It will be seen that the wave-lengths of the penetrating γ-rays from RaB and RaC are much shorter than any previously determined. (Moseley found strong line for silver, $0{\cdot}56 \times 10^{-8}$ cm.) The authors conclude, after considering Moseley's results on the spectra of the K series for the elements, that RaC, and probably also ThB, emits another type of characteristic radiation which is of higher frequency than for the "K" series. This is termed, for convenience, the "H" series, for evidence of a similar radiation will no doubt be found in other elements when bombarded by high-speed kathode rays. In conclusion it is shown that the relation $\nu = k\mu^{-2/5}$ (where ν is the frequency, μ the absorption coefficient in Al, and k is a const.) holds fairly well for these high-frequency radiations. **A. B. W.**

186. *Scattering of γ-Radiation.* **D. C. H. Florance.** (Phil. Mag. 28. pp. 363–367, Sept., 1914.)—A recent paper by the author [Abs. 814 (1913)] has shown that γ-rays emitted from RaC in traversing thin sheets of lead give rise to a complex secondary radiation. From these experiments it seemed probable that there existed some definite relation between the amount of secondary radiation emitted from different radiators and the atomic weights of the radiators. From the results of a large number of experiments, described in the present paper, it is shown that equal masses of different elements scatter the γ-rays from RaC to the same extent, *i.e.* the scattering per atom is proportional to the atomic weight of the different elements. Measurements of the penetrating power of the scattered radiation are also described. The author concludes that the penetrating power of the scattered radiation may become modified in its final passage through matter, but it depends essentially on the angle of scattering and not on the material of the radiator. A. B. W.

187. *Acquired Radio-activity.* **W. Crookes.** (Roy. Soc., Phil. Trans. 214. pp. 433–445, Dec. 16, 1914.)—The experiments described deal with the action of kathode and radium radiations on diamond and other substances. When diamond, ruby, garnet, gold, platinum, yttria, calcium sulphide, zinc blende, and barium platinocyanide are bombarded in a high vacuum by kathode rays, in no case can any permanent activity be recognised either by photographic or electrical means. By direct exposure to radium, however, many of the above substances become coloured, the colour depending on the substance. Diamonds take a full sage-green tint, the depth depending on the time of exposure. In addition to change of colour diamond becomes persistently radio-active, continuously giving off α-, β-, and γ-rays. The acquired colour and activity withstand the action of powerful chemical agents, and continue for years with apparently undiminished activity. Removing the surface by mechanical means, however, removes both colour and radio-activity.

A. B. W.

188. *Volatility of Thorium Active Deposit.* **T. Barratt** and **A. B. Wood.** (Phys. Soc., Proc. 26. pp. 248–260; Discussion, p. 260, June, 1914.)—The authors describe experiments in which an attempt is made to separate the components of the active deposit by heating the latter to various accurately measured temperatures and following the consequent changes of activity as measured by both α- and β-radiations. It is found that ThB and ThC each begin to volatilise at a temperature of about 750° (when measured by α-rays), and volatilisation is not complete even at 1200° C. The volatilisation curve of ThC is similar to two "β-curves" in series, the inflection occurring at about 900° where about 35 % of the α-activity has been removed. When measured by its β-activity, ThC volatilises at 900° and ThD at 500° C. In explanation of these results it is assumed that C_β is a separate product, which breaks up in two ways, each with the expulsion of an α-particle, producing C_α and C_2 as shown on the following scheme :—

$$\begin{tikzcd}
 & & & C_\alpha \arrow[r] & D \arrow[r] & ? \\
\text{ThA} \arrow[r] & \text{ThB} \arrow[r] & C_\beta \arrow[ur, "35\,\%"] \arrow[dr, "65\,\%"'] & & & \\
 & & & C_2 \arrow[rr] & & ?
\end{tikzcd}$$

The temperature of volatilisation when treated with conc. HNO_3 was found to be the same as for ordinary active deposit; the temperature of volatilisation in HCl is 300° for ThB and ThC. A. B. W.

189. *Distribution of Active Deposit of Actinium in an Electric Field.* **A. N. Lucian.** (Am. Journ. Sci. 38. pp. 539–555, Dec., 1914. Phil. Mag. 28. pp. 761–778, Dec., 1914.)—Recent work by Wellisch [Abs. 249 (1914)] has shown that the atoms of radium active deposit consist both of neutral and positively-charged particles. On the other hand, Walmsley's experiments [Abs. 101 (1914)] in the case of actinium active deposit seem to indicate that the *whole* of the active deposit is positively charged. There is a fundamental difference between the method adopted by Walmsley and that followed in the present investigation. In Walmsley's experiments the total activity was assumed to be equal to the sum of the activities obtained when the central rod was first made the kathode and then the anode. The author attempts to show that this assumption is not justifiable, and in his work the activities both of the case and of the central electrode are measured directly. The results obtained indicate that there is a definite percentage, about 95 %, of the active deposit which settles on the kathode, the remaining 5 % consisting of neutral particles. Both volume recombination and initial or columnar recombination have to be taken into account for a complete explanation of the experimental results. The author concludes that the actinium active deposit seems to behave, qualitatively at any rate, like the active deposit of radium.

A. B. W.

190. *Radio-activity of Hot Springs.* **S. Ono.** (Math.-Phys. Soc., Tōkyō, Proc. 7. pp. 419–422, Nov., 1914.)—The emanation-content of a large number of hot-springs in the province of Higo has been measured by an ordinary bubbling method. The amount of emanation per $cm.^3$ of water was found to vary in the samples examined from different localities from $1{\cdot}88 \times 10^{-12}$ to $0{\cdot}04 \times 10^{-12}$ curie. Varying amounts of CO_2 were found to be present in every case. Measurements were also made on the rate of production of emanation at different seasons of the year. A. B. W.

191. *Radio-activity of Mineral Springs.* **H. Ikeuti.** (Math.-Phys. Soc., Tōkyō, Proc. 7. pp. 422–424 and pp. 425–426, Nov., 1914.)—These papers contain the results of a series of measurements of the amount of RaEm in the waters of various "bathing-places" in Etigo and hot springs in Sinano.

A. B. W.

HEAT.

192. *Limits of Inflammability of Methane-Air Mixtures.* **M. J. Burgess** and **R. V. Wheeler.** (Chem. Soc. J., Trans. 105. pp. 2591–2596, Nov., 1914.)—The authors object to the criterion of inflammability of Coward and Brinsley (Ibid. p. 1859), who regard that mixture as limit-mixture in which flame can be propagated upward indefinitely and consider inflammability as a specific property, present or absent, of the mixture independent of shape or size of the vessel and of the nature of ignition. As the methane percentage in closed cylinders, 6 cm. diam., ignited by a spark at the bottom, is increased above 5·0, the authors find, the flame travels upward further and further, from 30 up to 50 cm. for 5·35 % ; with 5·4 % it travels the full 2 m. of the tube length ; whether it would travel indefinitely in longer tubes is not known. When travelling downward the flame changes its shape as it advances. In horizontal tubes the flame floats like a boat along the top of the tube ; 3·25 % of CH_4 (of the original 5·4 %) is afterwards found in the products of combustion, when the tube has a diam. of 6 cm., and 3·9 % when the diam. is 10 cm. If a large room were filled with a methane-air mixture, and ignited near the floor, the flame would probably rise and spread along the ceiling. When the methane percentage is 5·6, complete combustion is obtained in a large globe, ignited at the centre, and also when a flame travels downward in a 6·0 % mixture ; when the air is agitated by a fan 5 % suffices for complete combustion. For these reasons the authors do not wish to restrict the definition of limit-mixture to upward propagation of the flame. It is not done by miners. In mine air the percentage of firedamp is rarely uniform ; locally it may be high, and when local ignition takes place, the flame may slowly travel a long way near the roof ; such ignitions become dangerous chiefly because they may transmit flame to the coal dust. H. B.

193. *Uniform Movement of Flames in Methane-Air Mixtures.* **R. V. Wheeler.** (Chem. Soc. J., Trans. 105. pp. 2606–2613, Nov., 1914.)—Mallard and le Chatelier observed in 1883 that the flame travelling from the open end of a horizontal tube moved first at a uniform speed ; this "uniform movement" was followed by an irregular "vibratory movement" at higher speed during which the flame travelled forward and backward, and was sometimes extinguished. The uniform movement is the normal speed of flame propagation by heat combustion from layer to layer of the mixture, and is constant for a given mixture at given pressure and temperature ; the true speed would be obtained in a mixture of infinite extent. Mallard and le Chatelier experimented under varied conditions ; but their methane (from acetate) was probably very impure, and their tubes were small. The authors repeat the experiments. They join three lengths of 2 m. of glass tubes, 5 or 9 cm. in diam., by rubber tubing, fit end-pieces to the two ends and stretch fine copper wires in circuit with a chronograph across the tube. They do not confirm all of the previous observations. The speed rises with increased methane percentage, but is practically constant for the range 9·45 to 10·55 % ; any max. speed at 12 % (ascribed to a max. thermal conductivity of a mixture containing more than the amount of CH_4 necessary for complete combustion) was not observed with the higher and lower inflammability limits

of 5·4 and 14·3 % for horizontal propagation; the speed curve, moreover, became too flat to determine the theoretical limits of inflammability by intersection with the zero ordinate. The speed sometimes remained uniform throughout the tube, and was then the same for the lower and the higher limits. As the methane percentage increased the flame, travelling near the top in poor mixtures, filled the cross-section more completely, and the front of the advancing flame became more blunt. H. B.

194. *Thermostat for Low Temperatures.* **J. H. Walton, Jr.,** and **R. C. Judd.** (Journ. Phys. Chem. 18. pp. 717-721, Dec., 1914.)—The construction is described of a thermostat which can be kept constant at temperatures from 0° to about −20°. The general plan consists of a primary bath and a secondary bath. The primary bath is filled with a mixture of ice, salt, and water, which is pumped through a coil in the secondary bath. When the temperature in the latter becomes too low, a cock between the two baths, which is worked by a special arrangement connected with a mercury temperature regulator in the primary bath, is closed and the flow of the cold brine is shut off. Similarly, when the primary bath becomes too warm, the cock is opened, and the flow of cold brine lowers the temperature. A full description of the working parts is given. In a test carried out to ascertain the constancy of the thermostat it was found that at a temperature of −12°, during a run of 6 hours, the temperature varied ± 0·03 deg. T. S. P.

195. *Velocity of the Crystallisation of Undercooled Water.* **J. H. Walton, Jr.,** and **R. C. Judd.** (Journ. Phys. Chem. 18. pp. 722-728, Dec., 1914.)—Using the thermostat mentioned in the previous Abstract the authors have determined the linear velocity of crystallisation of water at temperatures down to −9°. A glass tube was used to contain the water and successive measurements made with the same filling of water gave the same results as were obtained by refilling the tube each time an experiment was carried out. The velocity of crystallisation was found to increase slowly with lowering of temperature to about −6°, and then more rapidly to −9°, but because of spontaneous crystallisation it was impossible to determine the temperature of the max. velocity of crystallisation. The size of the bore and the thickness of the walls of the crystallising tubes are important factors in the velocity of crystallisation, inasmuch as they determine the rate of the cooling of the crystallising liquid; the results given above hold for a tube with outside diam. of 12 mm. and inside diam. of 7 mm. Tubes with very thin walls could not be used owing to spontaneous crystallisation occurring very readily. With the same volume of water undercooling is more easily carried out in a flask than in a tube; the water can be cooled to a lower temperature, and there seems to be less danger of spontaneous crystallisation. T. S. P.

SOUND.

196. *Minimum Duration required for Identifying Sounds.* **G. Gianfranceschi.** (Accad. Lincei, Atti, 23. pp. 704–706, May 3, 1914.)—The minimum duration required is approximately the same for all notes, and amounts to about 1/40 sec. When the ear is specially trained for them, as in the case of vowel sounds, the time can be as low as 0·01 sec. The estimates were made by hearing the sounds in a telephone in a circuit which could be completed for a known fraction of a second. E. E. F.

197. *Motions of Bowed Strings and Bow.* **C. V. Raman.** (Indian Assoc. for Cultivation of Science, Bull. No. 11, pp. 43–52, 1914.)—Helmholtz and others considered that the forward speed of the bowed point of a string was possibly equal to that of the bow. The present author has shown that to be the case in the following manner. A fairly long string is chosen for the experiment, and a narrow slit cut in a sheet of metal is set across and immediately behind the string. The positive crater of a small arc provides the necessary illumination. The string is bowed at a point as close as possible to the position of the illuminated slit. A pin is fixed transversely at the centre of the bow. A photographic plate contained in a dark slide is arranged to slide in grooves parallel to the string, and the movement is timed so that the shadow of the pin fixed to the bow passes across the illuminated slit when the photograph is being secured. A simultaneous record of the motion of the bow and of the vibrations of the bowed point of the string are thus secured. This method shows the two speeds in question to be identical. Three reproductions of such records are given in the paper. E. H. B.

198. *Influence of Meteorological Conditions on the Propagation of Sound.* **H. Bateman.** (Monthly Weather Rev. 42. pp. 258–265, May, 1914.)—An historical survey of the work which has been done, whether experimental or theoretical, on the above subject. The influence of wind and inequalities of temperature are dealt with, also fog signals; and the paper concludes with a bibliography of 75 references. E. H. B.

199. *Areas of Silence and Range of Sound.* **A. Mallock.** (Roy. Soc., Proc. 91. pp. 71–75, Nov. 2, 1914.)—Shows mathematically that a ray of sound starting horizontally at the earth's surface may be turned up and then down again, following a harmonic curve, provided the wind is everywhere horizontal and against the sound but of zero speed on the ground-level, increasing to a maximum speed at a certain height and falling to zero at double that height. In the case illustrated by graphs the sound is well heard at 5 miles' distance, but a silent area intervenes from about ¾ of a mile to 3¾ miles from the source. It is also shown that a temperature gradient may account for silence zones followed by areas of audibility. E. H. B.

200. *Acoustic Phase-difference at the Ears.* **G. W. Stewart.** (Phys. Rev. 4. pp. 252–258, Sept., 1914.)—The experiments in sound localisation (by Rostosky, by Rayleigh, by More and Fry and by Myers and Wilson) show that there is an illusion of localisation if there are produced at the ears various differences in phase obtained from the same source of sound or from sources of the same frequency. The present paper treats mathematically the acoustic shadow of a rigid sphere and applies the result to the phase-difference at the ears regarded as diametrically opposed on such a sphere. The results are presented in tables and graphs. [See Abs. 688 and 1040 (1907.)] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

201. *Electronic Charge by Millikan's Method but with Solid Spheres.* **J. Y. Lee.** (Phys. Rev. 4. pp. 420–434, Nov., 1914.)—The value of the elementary electric charge was very carefully determined by Millikan by his well-known method [Abs. 116 (1914)]. By varying the size of his drops and the pressure he also obtained empirically a correction term for the law of Stokes on the rate of fall of spheres in viscous media. These experiments by the present author were undertaken for the sake of seeing (1) whether solid spheres would give a value of e in any way different from that obtained with liquid drops, and (2) whether the correction term (A) to Stokes' law is the same for both solid and liquid drops. The apparatus used was slightly modified from Millikan's. The substance in liquid form is blown in very minute particles, by means of a commercial atomiser, into the dust-free chamber, where the drop solidifies and falls slowly to the top of the plate condenser near the bottom of the chamber. Some of the particles fall through the small holes in the middle of the upper plate into the space between, where, on account of the charge which they carry, they may be pulled upwards against the action of gravity by applying an electric field of sufficient strength and of the proper sign to the condenser plates.

After the experiments were carried out and the observations reduced the final mean value is $e = 4{\cdot}764 \times 10^{-10}$ e.s. unit. This value agrees to within one-fifth of one per cent. with the value obtained by Millikan with the oil-drops. But the uncertainty of the density of shellac is one-half per cent., so that the difference is within the limits of experimental error.

The value of A, however, is about 20 per cent. higher than Millikan's value, and this can be explained only by assuming that the coefficient of slip between oil and air is different from that between shellac and air. E. H. B.

202. *Direct Determination of "h."* **R. A. Millikan.** (Phys. Rev. 4. pp. 73–75, July, 1914. Paper read before the Amer. Phys. Soc.)—The experiments here reported were undertaken for the sake of subjecting to rigorous experimental test the three assertions contained in A. Einstein's photoelectric equation [Abs. 1228 (1906)]. These assertions are :—(1) That there is a linear relation between the frequency of the impressed light and the max. energy of emission of the electrons ejected by it. (2) That the slope of the line representing the linear relation between p.d. and ν is $h \div e$, or that the product of this slope and e is Planck's "h." (3) That the intercept of the p.d. line on the ν-axis gives the frequency ν_0 at which the metal in question first begins to be photoelectrically active.

The second and third of these assertions have not heretofore been made the subject of accurate test, nor can they be so made without simultaneous measurements *in vacuo* of both contact-potentials and photo-potentials in the case of metals which are sensitive throughout a long range of frequencies. The spectral lines used in the work must further be strictly monochromatic and of frequency determinable with a high degree of precision. The present measurements made on sodium from 6800 to $\lambda = 2300$ fully confirm the linear relation between p.d. and ν found by Kadesch [Abs. 1576 (1914)], and, further, they fix the value of the slope, *i.e.* of h/e, at $4{\cdot}123 \times 10^{-15}$

volt/frequency, with an error of not more than a half per cent. Inserting the author's value of e, viz. $4{\cdot}774 \times 10^{-10}$, which is thought to be correct to within 0·2 per cent., there results from the above value of h/e the determination $h = 6{\cdot}561 \times 10^{-27}$. This value of h combined with the author's value of e gives, with the aid of Planck's equation, the following value for the constant of total radiation: $\sigma = 5{\cdot}688 \times 10^{-5}$, which is very close to the value obtained by Coblentz from a study of all the data available. Again using the author's e with this σ and substituting in Planck's equation, the Planck-Wien constant of spectral radiation is found to be $c_2 = 1{\cdot}434$, which is within one part in 700 of the latest Reichsanstalt value of this constant. The value of ν_0 obtained for sodium, the metal upon which all these experiments have been made, is $\nu_0 = 0{\cdot}439 \times 10^{-15}$, which corresponds to $\lambda = 6800$. Planck's constant "h" is thus found to stand out in connection with photoelectric measurements, perhaps more sharply and more exactly than in connection with any other type of measurements thus far made. E. H. B.

203. *The Thunderstorm and its Phenomena.* **W. J. Humphreys.** (Frank. Inst., J. 178. pp. 517–560, Nov., and pp. 751–776, Dec., 1914. Monthly Weather Rev. 42. pp. 348–380, June, 1914.)—After a brief introduction, the paper opens with an account of Simpson's theory of the production of electricity in thunderstorms. An essential condition demanded by this theory is the existence of rapid vertical convection of humid air, and apart from theory such convection in a very active form may be inferred from the presence of the hail which frequently accompanies these storms. The conditions under which the vertical temperature gradient necessary for the production of this convection can be established fall into three classes: (1) strong surface heating, (2) the overrunning of one layer of air by another at a temperature sufficiently lower to induce convection, and (3) the underrunning and consequent uplift of a layer of saturated air by a denser layer, in which case adiabatic expansion cools the saturated layer less than the superincumbent unsaturated layer, and thus leads to instability. The second class represents the predominating cause of ocean thunderstorms. Land thunderstorms tend to occur periodically with three chief periods: (*a*) the daily, with max. frequency in the afternoon when the earth's surface is most heated, (*b*) the yearly, with maximum in the hottest months of the year, and (*c*) an irregular cyclic period with maximum occurring in warm and wet years. Five types of pressure distribution are enumerated, and illustrated by isobaric maps, as being distinctly favourable to the production of thunderstorms. In each case there is a tendency for an adiabatic or even superadiabatic temperature gradient to be established in the lower layers of the atmosphere, with consequent production of unstable conditions.

In considering the mechanism of a thunderstorm it is found that a rapid and concentrated downward current of cold air is as pronounced a feature of the phenomenon as the uprush of heated air, and after taking account of various possibilities it is concluded that the evaporation of falling rain-drops forms the necessary and sufficient means by which the cold down-current may be maintained. Thus after local convectional up-currents have been formed it is still necessary for rain to be produced by condensation and to fall to lower levels where evaporation can take place in drier air before the full thunderstorm mechanism can be established. Diagrams are reproduced to show the violent up and down currents, rain, and other features of a well-developed storm.

The second part of the paper deals with the detailed phenomena which

form an inseparable part of thunderstorms. It is noticeable that extra heavy rain often follows quickly after a loud clap of thunder. The explanation put forward is that both thunder and rain are the result of a period of exceptional activity in the upper part of the storm. This leads to excess electrical discharge with consequent thunder, and also to the formation of excess rain, which reaches the earth shortly after the thunder is heard. The different types of lightning-flash are described and illustrated, and an interesting suggestion is put forward as to the method by which the path which a flash is about to take through the air may be built up. Different, and less common, forms of lightning discharge, as ball lightning, are also considered. The question as to whether lightning discharges are uni-directional or alternating is entered into, and strong evidence is produced against the alternating theory. The formation of thunder is ascribed to the sudden and violent heating of the air along the path of the flash, with consequent explosively rapid expansion. Many other features are also considered.
J. S. Di.

204. *Investigation of Causes Responsible for Uncertainty in Measurement of Atmospheric Conductivity by Gerdien Conductivity Apparatus.* **C. W. Hewlett.** (Terrest. Magnetism, 19. pp. 219–233, Dec., 1914.)—If the air current flowing between the inner and outer cylinders of the instrument is non-uniform in cross-section too low a value may be found for the conductivity. This can be corrected by reducing the p.d. between the cylinders. The max. value of this p.d. which may be used if correct results are to be obtained has been found to vary considerably on different occasions. With the apparatus as usually constructed the value should not exceed 60 volts in order to avoid any risk of error from this cause. The charge induced on the earthed portions of the instrument can, under certain circumstances, greatly affect the conductivity reading for the ions of like sign to the induced charge. For this reason it is better, when the potential gradient is high, that the instrument should not be earthed but insulated and kept uncharged by means of a water-dropper placed upon it.
J. S. Di.

205. *Theory of Atmospheric-electric Measurements.* **W. F. G. Swann.** (Terrest. Magnetism, 19. pp. 205-218, Dec., 1914.)—When an electrical apparatus is exposed in the earth's field and connected to earth a charge is induced upon it, the sign of which is normally negative. It is the purpose of the present paper to examine the influence of this induced charge upon the readings of certain electrical instruments. In the Ebert ion-counter the number of negative ions which enter the end of the outer cylinder will be reduced by the action of this induced charge, and from some experiments made it is estimated that an error of 26 % may in certain circumstances be made in the determination of n_-. In the case of positive ions there will be two opposing influences at work and these will counterbalance one another, so that no error will be produced. This may account for the fact that a greater number of positive than of negative ions is often found when measurements are made with the Ebert apparatus. The effect produced on Gerdien's conductivity apparatus is also considered. The question is then raised as to the desirability of enclosing the whole equipment under an earthed hemispherical shield of wire netting, and it is concluded that some improvement in the measurement of n_- might be obtained by adopting this plan. Finally it is urged that measurements of ionic density should be made from the top of a high tower, remote from the disturbing influence of the earth's surface.
J. S. Di.

DISCHARGE AND OSCILLATIONS.

206. *The Spectrum, Temperature, and Brightness of the Crater in the Carbon Arc.* **A. Amerio.** (Elettrotecnica, 1. pp. 672–681, Oct. 25, 1914.)—This paper which is divided into four sections deals, among other things, with the following points:—The heat emitted by the arc; The heat emitted by the negative point of the carbon; Measurement of the total energy by means of a bolometer; Variation of the emission along the arc; Observations on the results obtained. Diagrams of the apparatus used and illustrating the results obtained are given. It is concluded that the temperature of the crater is about 3800° to 4000° C.—probably much nearer the latter than the former value. The temperature of the point of the negative carbon is about 3000° to 3250° C. The brightness of the crater is estimated as 16,600 Hefner units.

A. E. G.

207. *Calcium and Magnesium Vapour Lamps.* **F. A. Saunders.** (Astrophys. Journ. 40. pp. 377–384, Nov., 1914.)—Lamps similar to the mercury arc, but working with the vapours of Cd or Zn have previously been made. More recently Paschen succeeded in running a lamp with the vapour of thallium [Abs. 1875 (1909)]. At Paschen's suggestion the author undertook to make a calcium-vapour lamp, and in the end, vapour lamps were successfully run in a quartz tube both with Ca and Mg. The spectra of these lamps are examined from λ9000 to λ2000, and, in a preliminary sort of way, in the Schumann region. The first part of this work will be dealt with later; the present paper describes the new vapour lamps and the experiments in the Schumann region. A quartz tube was used 30 cm. long and 1 cm. internal diam., and side tubes were attached near the middle for the terminals; these were 7 cm. apart. The ends of the long tube were ordinarily closed by quartz plates, attached by white wax and kept cool by wet cotton. The terminal tubes were each filled with about 1 cm.^{3} of small lumps of Ca (or Mg), into the under part of which were inserted copper wires, which were led out through long narrow bent tubes, dipping under water (for cooling) and sealed air-tight at the ends with wax. Connection with an air-pump was made through a side-tube midway between the electrodes. The middle portions of the tube and the metal in the electrodes were heated red-hot and exhausted. After this the arc usually started easily; sometimes it was sufficient merely to close the 220-volt connection, and ionise for a moment the residual gas in the tube by a discharge from an induction coil; but more often a certain amount of preliminary heating was also necessary. The arc was intensely brilliant; the colour being bluish-white with Ca and greenish-white with Mg. The end windows remained clear for a long time if the tube was air-tight and the current not more than 4 or 5 amps. For the experiments in the Schumann region the lamp was attached directly to a vacuum grating spectrograph, one of the quartz plates having been removed from the end of the lamp. Thus the light went directly from the luminous vapour through the slit to the concave grating, and was returned to the Schumann plate, passing on its way through nothing but the very small amount of residual gas (mostly hydrogen) in the spectrograph. The spectra of Zn and of Ca, and incidentally of hydrogen, were photographed to a limit somewhat beyond λ1000. The Ritz series of hydrogen lines has been photographed as far as λ1026, and it was found to be practically independent of the secondary spectrum. The spectrum of the calcium lamp in the Schumann region is almost the same as was obtained by Lyman from a spark. A table is given of the wave-lengths of the lines measured, with Lyman's results for comparison. Lines were observed in the case of Zn as far as λ1099·6, but the lines as yet are not positively identified. An interesting feature of the calcium lamp is that it acts like a chemical air-pump, removing the gases with which the Ca combines. A. W.

208. *Effects of Magnetic Field upon Negative Luminosity.* **L. Puccianti.** (N. Cimento, 8. pp. 109–122, Aug., 1914.)—Confirms Righi's results [Abs. 1582 (1914)]. The conditions under which the kathode bundle of rays assumes, under the influence of an electromagnet, an appearance of bright nodes and loops, the length of the loops increasing with the distance from the kathode or the polar face of the electromagnet and decreasing when the electromagnet is strengthened, are investigated. The nodal figure really consists of a double infinity of helices; this is dealt with mathematically. Superposition of the helices gives resultant envelopes analogous to caustics, which in the simplest cases have sinusoidal outlines. A. D.

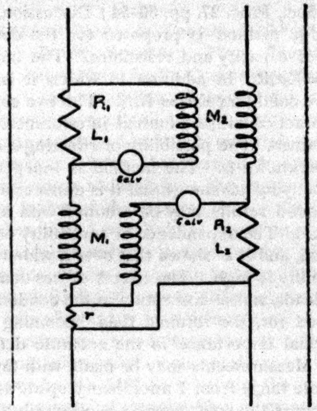
209. *Absorption of Hydrogen by Sodium-Potassium Electrodes.* **R. C. Gowdy.** (Phys. Rev. 4. pp. 401–408, Nov., 1914.)—The author investigates the behaviour of Na-K alloy used as kathode or anode in a glow discharge in hydrogen. The rate of absorption of hydrogen by Na-K kathodes is measured for various currents. At current densities less than 0·5 milliamps. per cm.^{2} the rate of absorption is about 10 times that at which hydrogen is liberated by electrolysis by an equal current. For greater current densities the rate of absorption is constant; it increases with the temperature of the kathode. When the alloy is used as anode at pressures of 1 or 2 mm. hydrogen is absorbed, at low pressures it is evolved. Hence there should be some "equilibrium pressure" at which neither absorption nor evolution occurs. This pressure is found; it depends on the current and on the amount of hydride on the surface of the alloy. The rate of evolution by anodes below the equilibrium pressure is measured for different currents. It is also shown that Na and K hydrides are decomposed by kathode rays.

It is known that the hydrides are formed at a temperature of 350° C. and decomposed about 400° C. Assume that when the alloy is struck by a charged particle of sufficient velocity a local heating effect is produced. At the point of impact the temperature is above the decomposition temperature of the hydride, but in a zone round it conditions exist suitable for formation of hydride. Then at any instant a certain fraction of the surface is in a state suitable for decomposition of hydride and a fraction suitable for its formation, so that both evolution and absorption of hydrogen are occurring. If the evolution overbalances the absorption the resultant effect is an evolution of hydrogen, and *vice versâ*. Along these lines the author explains the results he obtains. T. H.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

210. *Resistivities of Glass and Fused Silica at High Temperatures.* **A. Campbell.** (Phys. Soc., Proc. 25. pp. 336–337, Aug., 1913. From the National Physical Laboratory.)—A few results are given of some tests of the insulation resistance of fused quartz, glass, and mica at various temperatures, the first two substances being tested in the form of tubes and the mica as sheet. At 750° C. Jena combustion glass conducts fairly well (resistivity 0·01 to 0·04 megohm-cm. as compared with 2×10^8 at 18° C.). L. H. W.

211. *Time Constants of Low Resistances.* **F. Wenner, E. Weibel,** and **F. B. Silsbee.** (Phys. Rev. 4. pp. 71–72, July, 1914. Paper read before the Amer. Phys. Soc.)—Describes two new methods for measuring the time-constants of low resistances. The first method gives primarily the sum of the time-constants of the two resistances used. By using 3 resistances 3 sums can be measured from which such time-constants can be obtained, without calculation of the inductance of a resistance standard. In this method the resistances are each connected in series with a mutual inductance as indicated in the Fig. and excited by alternating currents substantially in quadrature. The constants of the circuits are then adjusted so that no current can flow in either galvanometer. It can easily be shown that the following relations then hold: $R_1R_2 = p^2(M_1M_2 + L_1L_2)$ and $pL_1/R_1 + pL_2/R_2 = prM_2/R_1R_2$ or r/pM_1 very closely, where $p = 2\pi \times$ frequency. The second method makes use of a standard whose resistance can be changed without changing its inductance. Then if the observed decrease in phase angle be $\Delta\theta$ and the corresponding proportional increase in resistance be a we have $pL/R = \Delta\theta(1 + a)/a$. This method requires merely an accurate measurement in the phase angle.



F. E. S.

212. *Silver Voltameter.* **T. M. Lowry.** (Roy. Soc., Proc. 91. pp. 58–71, Nov. 2, 1914.)—In an earlier paper [Abs. 868 (1908)] it was shown that the weight of silver deposited by a given current was influenced in an important degree by impurities in the silver nitrate solutions. The most important impurities are those which are capable of exerting a reducing action upon the silver nitrate, but there is also a group of substances to be considered which are soluble in silver nitrate solutions though almost insoluble in water. The first of such substances to be investigated was silver chloride, and its solubility in solutions of silver nitrate of various concentrations and at different temperatures was determined by a gravimetric and a volumetric method. The solubility of the chloride increases with the concentration of the nitrate and increases also with the temperature. The solubility of silver chloride in solutions of common salt and hydrochloric acid was also determined, the results showing that common salt is a better solvent for the chloride than is silver nitrate and that the max. amount of silver chloride dissolved is practically the same for NaCl and HCl—namely 2 gm. of AgCl per 100 gm. of NaCl or HCl. In the case of the solubilities of silver bromide, iodide, and sulphide in solutions of silver nitrate the results are complicated by the formation of double salts. The solubility of the bromide is 3 or 4 times as great as that of the chloride, and of the iodide about 100 times as great.

F. E. S.

213. *Measurement of Self-induction in Terms of Capacity and Resistance.* **D. Owen.** (Phys. Soc., Proc. 27. pp. 39–54; Discussion, pp. 54–55, Dec. 15, 1914.)—An a.c. bridge method is proposed for the determination of self-induction in terms of capacity and resistance. The inductance L is given by the relation $L = K_3 r_1 R$; in addition to which it is also necessary for balance to satisfy the condition $K_3 r_1 = K_4 r_2$. The two conditions of balance may be secured in practice without mutual interference. The end point is therefore rapidly attained. The possibility of effecting a balance is unlimited by the value of the unknown L. The method is independent of frequency. This has the accompanying advantage that it is unnecessary to employ a pure sine voltage. Very good results may be attained with a buzzer and a telephone, at say 500 ∿. The dependence of sensibility of the bridge on the frequency is discussed, and it is shown that over a wide range (*e.g.* 100 ∿ to 1000 ∿) the sensibility is high. The effects of residual inductance in the resistance coils and leads, and of absorption in the condensers, may be simply and correctly allowed for, the formula then becoming $L = K_3 r_1 [R - R_0]$. This fact is of especial importance in the accurate determination of very small inductances. Measurements may be made with the same pair of condensers over the whole range from 1 microhenry upwards. For inductances of about 10 microhenrys the error may be kept within a few parts in 1000; while for a few millihenrys the error may be below one part in 10,000. The application of this bridge to the determination of capacity in terms of inductance is discussed. In the *discussion*, **A. Campbell** pointed out that one of the disadvantages was the use of standard condensers in place of standard inductances. The latter could be obtained at less cost and of greater accuracy than condensers. He suggested that, on account of earth capacities, it would be better if the galvanometer and battery were interchanged. **F. E. Smith** mentioned that it was always dangerous to cool a paraffin wax condenser to 0° C., as a change occurred in the wax. **A. Russell** said that he had obtained good results with the author's method, using either a telephone or a vibration galvanometer and the ordinary a.c. supply. I. W.

214. *Radium as a Lightning Conductor.* **B. Szilard.** (Soc. Int. Élect., Bull. 4. pp. 669–685; Discussion, pp. 686–687, July–Dec., 1914.)—The ordinary point lightning conductor is discussed from an efficiency standpoint and its limitations are explained. The author then proposes an ionisation method for preventing electric storms by means of radium, disclaiming originality, however, by a reference to Arago in which flames were used with the same object. We now know that the flames would ionise the atmosphere; the radium, however, would exert other influences in addition to ionisation towards the same end. A considerable section of the paper is then devoted to an exposition of the influence of radium emanations upon the electrical conductivity of air. Following this comes a theoretical discussion of the effects which would follow if an ordinary lightning conductor were furnished with a radium-covered screen placed beneath the point. The net result

would seem to be a progressive conductivity of the air towards the point, which would promote the electrical flow in this direction. A detailed description next follows of a radium-furnished instrument for the practical study of the subject. The apparatus was provided with a suitable installation for the quantitative examination of the phenomena observed. The whole scheme was specially designed for easy portability. The results obtained, both with and without the presence of radium, are well explained and illustrated by a series of comparison curves. The author believes that work on these lines merits further investigation. [See Abs. 1820 (1914).] H. H. Ho.

215. *Effects of Residual Gases on Contact E.M.F.'s and Photo-currents.* **R. A. Millikan** and **W. H. Souder.** (Phys. Rev. 4. p. 73, July, 1914. Paper read before the Amer. Phys. Soc.)—Curves representing both the variation of contact e.m.f.'s and saturation photo-currents with time have been taken on freshly-cut sodium surfaces both in the best vacuum obtainable with a Gaede molecular pump and in vessels containing residual gases. The most striking characteristic of the photocurrent-time curves is that they are of altogether different form according as the frequency of the light with which they are taken is that of the extreme ultra-violet or that of the visible spectrum. Thus, when tested with light of wave-length 5461 Å. the photosensitiveness of a *freshly-cut* sodium surface is zero. It rises with time to a considerable value and finally falls again to zero. When tested, however, with light of wave-length 2535 Å. this same surface shows a large initial photosensitiveness which falls off steadily with time to zero.

The observed phenomena are interpreted as follows: A freshly-cut sodium surface is not sufficiently electro-positive to respond photo-electrically to light of wave-length 5461 Å., but under the influence of an active gas the sodium forms a new substance which is more electro-positive than the freshly-cut sodium, and hence is photo-sensitive to longer waves. The photo-curve taken with wave-length 5461 Å. represents then merely the growth and decay of this substance. For sufficiently short waves, however, the freshly-cut surface is itself so photo-electrically active that its own decay curve completely masks the rise and fall curve due to the growth and decay of the more electro-positive substance resulting from the action of gas upon the sodium.

Further experiments on potassium and lithium are in progress. E. H. B.

216. *The Induction Coil.* **U. Magini.** (Elettrotecnica, 1. pp. 787–788, Dec. 5, 1914.)—Describes an induction coil of which the secondary is composed of two separated coils of relatively thick wire 0·4 mm. diam. The core is formed of iron sheets insulated with paper. The max. effect is obtained when the two secondary coils are a certain distance apart. With 20 to 30 amps. and 150 volts in the primary a flame spark of 17 cm. is obtained at the secondary between a point and a positive disc, and a current of 50 milliamps. It is claimed that this coil is extremely cheap and light.

E. B.

217. *New Electrometer for Radio-active Investigations.* I. **H. J. Folmer.** (K. Akad. Amsterdam, Proc. 17. pp. 659–671, Nov. 27, 1914.)—The principle and mode of action of an electrometer, specially designed for measuring minute ionisation currents, such as currents produced by the radiations from potassium, rubidium, etc., is described. The instrument is the result of an attempt to combine the favourable qualities (great sensi-

bility, etc.), of the Wilson gold-leaf electroscope and the Dolezalek electrometer. The author states with regard to the measuring system: "The principle of it differs from that of the quadrant electrometer; it has been thus chosen on purpose that the lines of force formed by the ionisation current contribute as *much* as possible and as *favourably* as possible to the movement of the needle. This is not the case with the quadrant electrometer; there the movement is caused by the lines of force which run between the quadrants and the rims of the needle, whereas the vertical lines of force between needle and quadrants do not contribute anything to the moving couple." Experimental results are given, showing the method of measuring very small currents and of determining the limits of sensibility. A. B. W.

218. *Demonstration of some Alternating-current Phenomena.* **K. Otobe.** (Math.-Phys. Soc., Tōkyō, Proc. 7. pp. 417–419, Nov., 1914.)—A simple arrangement is contrived whereby the single-phase current of a 3-wire a.c. system is split into two branches with different phases by means of a suitable inductance and lamp resistance. Making use of this rotating magnetic field various experiments, including an illustration of the principle of the squirrel-cage rotor, are described. A. B. W.

ALTERNATING CURRENTS AND MAGNETISM.

219. *High Permeability in Iron.* **E. Wilson.** (Roy. Soc., Proc. 91. pp. 104–105, Dec. 1, 1914.)—An appendix to a former paper [Abs. 1736 (1914)], elucidating a point which had remained unsettled. Work by Pender and Jones [Abs. 828B (1913)] is referred to, and it is stated that it is not necessary specially to shield iron from the earth's magnetism in order to obtain high max. permeability by cooling the iron through the critical temperature in a steady magnetic field. G. E. A.

220. *Fatigue of Nickel and Iron Wires in Alternating Magnetic Fields.* **W. Brown.** (Roy. Dublin Soc., Proc. 14. No. 26. pp. 336–344, Jan., 1915.) —The wave-forms of the alternating currents employed in previous work [Abs. 1027 and 1332 (1914)] contained the third harmonic; the present communication gives results caused by very nearly pure sine wave magnetic fields of frequency 50. The nickel wire, while sustaining a longitudinal load, carried a current of 1 amp., and the corresponding current was put through the magnetising solenoid to give the magnetic field which produced the greatest twist of the lower end of the wire (deflection, D). The equivalent r.m.s. alternating current was then passed round the solenoid for 1 minute. The direct currents were then sent, as before, through the wire and round the solenoid, and the twist observed (deflection, d). This process was repeated until the twist was no longer diminished by the alternating field. The fatigue was then measured by $(D - d)/D$. The results for nickel show that the greater the rigidity the greater is the fatigue, and as the longitudinal load increases the fatigue decreases. The limits of rigidity between which nickel is and is not sensitive to fatigue are very narrow. Iron wire is not so easily fatigued by the application of alternating fields as nickel. In a comparatively soft state the iron wire showed no trace of fatigue when subjected to the alternating field for one hour. A change of about 2 % in the rigidity made all the difference between fatigue and no fatigue. G. E. A.

221. *Magnetic Disturbances in* 1913. **L. F. Richardson.** (Nature, 94. p. 450, Dec. 24, 1914.)—This is an account of an examination, undertaken on W. N. Shaw's instructions, of the Eskdalemuir magnetograms for 1913. The disturbances from the level of the quiet day inequality fall into two classes, A and B. A is due to a magnetic force remaining in a more or less fixed direction while changing sign in an oscillatory manner, and appears to resemble the type of disturbance attributed by Birkeland to a ring-shaped electric current encircling the earth at a great height above the ground in the plane of the magnetic equator. In B the direction of the disturbing magnetic force was not fixed as in A, but wandered about, usually remaining within 60° of a plane normal to the undisturbed force, and B appears to resemble the types of disturbance which Birkeland has called "polar" and "cyclo-median." A sometimes occurred without B, but B seldom without A. Details accompany the note. H. H. Ho.

222. *Variations of the Earth's Magnetic Field.* **S. R. Williams.** (Science, 40. pp. 606–607, Oct. 23, 1914.)—Experiments are described with the intention of finding evidence of the connection of earth currents and variations of the magnetic field. The test strip consisted of a shallow tray of mud made with acidulated water, placed in series with a galvanometer. The surface of the mud was heated by means of a bunsen flame. When the flame was moved slowly along the length of the strip a current was produced in the direction opposite to the motion of the flame. It is suggested that a similar effect may be produced by the sun's heat acting on different portions of the earth's crust, by reason of the earth's rotation, in which case the resulting earth current should be from west to east. In the laboratory experiment it was found that by increasing the heat of the flame the galvanometer deflection became greater, thus suggesting that the terrestrial current should be stronger in the tropical regions where the solarisation is greatest. This would result in two systems of current sheets, north and south of the equator, whose directions would be opposite. As these current sheets advance westward their magnetic fields would affect magnetometer needles so as to produce westward deflections in the northern hemisphere and eastward deflections in the southern hemisphere, followed later in the day by reversed deflections in both cases. It is hoped to find conditions in which the current directions are the same as the heating directions, as it is known that thermoelectric phenomena are of wide divergencies; land areas, for instance, may well give different results from oceanic areas. Variations of atmospheric phenomena, such as rain, wind, and cloud, may also prove to be important factors in the phenomena. C. P. B.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

223. *Electric Discharge of the Isolated Electric Organ of Astrape (Japanese Electric Ray) by means of an Oscillograph.* **K. Fuji.** (Math.-Phys. Soc., Tōkyō, Proc. 7. pp. 369–397, Oct., 1914.)—It is now some twenty years since the discharge curves of electric organs began to be investigated, but the curves obtained by the early investigators are not sufficiently accurate to be analysed quantitatively, and so in 1906 the present author began a course of experiments by means of an oscillograph on the fish called *Astrape Japonica.* A description of the fish and mode of discharge of the electric organ is first given, followed by exhaustive details of the experimental plan adopted. A diagram of the apparatus is also included. Several plates of the discharge curves are given, the form of these resembling the probability curve of Gauss except in not being symmetrical with respect to the max. ordinate. The following assumptions were made: (1) The discharge of each electric plate caused by a single stimulus is of very short duration. (2) There exists a time interval in latent state between the stimulation instant and the resulting discharge, which interval may be called the latent period of the single plate. (3) These intervals differ in electric plates, but there is a certain value predominating in its number, the other values deviating more or less from it according to the law of errors in somewhat modified form. The predominating value of the latent periods just mentioned will be called the modal latent period; a formula expressing a curve that agrees very closely with the experimental discharge curve was then obtained. The experimental curves then receive detailed examination, numerous tables and diagrams being given, and of the conclusions drawn the following are those of physical interest, the remainder being mainly of physiological importance: (1) A formula expressing the time relation of a single discharge is expressed by $y = Ae^{-b^2}\log^2 x/x_0$, where y denotes the e.m.f. at a time x measured from a certain fixed movement, x_0 and b^2 being constants. (2) In the case of the direct stimulus of short duration the origin of time in this formula is at the instant of stimulation. (3) When the direct stimulation is of longer duration the discharges in response to it may be analysed into two simple discharges, corresponding to the closing- and opening-stimulus, and each of them may be represented by the above formula, having its origin at the respective stimulus. (4) Taking the value of A as the measure of the excitation, the relation between the intensity of a stimulating current and the excitation in response forms an S-shaped curve which rises from the zero stimulus very slowly, then quickly, and after passing an inflection point on its way, finally approaches asymptomatically a constant maximal value. (9) The abnormal increase in the intensity of the second of the discharges evoked by two successive stimuli may be interpreted by the superposition of the secondary discharge. (13) The fatigue curve in the case of the electric organ very closely resembles that of the contraction of muscle. (16) A spontaneous discharge curve of the living fish Astrape consists always of two peaks, sometimes followed by a very low irregular one. (17) The prolongation of the modal latent period from the normal, of whatever cause it may be, is necessarily accompanied by the enfeeblement of the discharge, while the feeble discharge evoked by the weak stimulus does not indicate the same prolongation. H. H. Ho.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

224. *Action of Radium Emanation on an Explosive Mixture of Gases.* **O. Scheuer.** (Comptes Rendus, 159. pp. 423–426, Aug. 17, 1914.)—A collection of experimental results is given showing the action of α-rays from RaEm on an explosive mixture of hydrogen and oxygen. The following conclusions are drawn from the tabulated results:—(1) The combination of hydrogen and oxygen is very intense; in one particular case accompanied by the explosion of the gas-holder. (2) The ratio b/a, where b is the number of mols. of gas which recombine per curie-second and a is the number of pairs of ions formed per curie-second, is constant but much greater than unity (the value of b/a in the decomposition of water). This is completely explained by allowing for the heating effect, independent of the impact of the α-rays. (3) Analysis of the gas shows the formation of H_2O and H_2O_2, certain considerations leading the authors to believe that the water is formed chiefly by the decomposition of H_2O_2. The analyses also prove the entire absence of ozone. Since ozone cannot exist in presence of H_2O_2 and mercury, the authors repeat the experiments on oxygen under similar conditions, thus showing that hardly a trace of ozone is formed. A. B. W.

225. *Cobalt and Cobalt Alloys. I. Reduction of Cobalt from the Oxide.* **H. T. Kalmus.** (Canada Dept. Mines, No. 259 [86 pp.], Ottawa, 1913. Journ. Engin. Chem. 6. pp. 107–116, Feb., 1914. Engineering, 99. pp. 181–182, Feb. 12, 1915.)—On behalf of the Canada Department of Mines the Queen's University at Kingston, Ontario, is investigating cobalt and its alloys, the work being in charge of Kalmus, C. W. Day, C. Harper, W. L. Savell, and R. Wilcox. The Deloro Mining and Reduction Co. has placed 1000 lbs. of black cobalt oxide at the disposal of the investigators. Of the eleven oxides assumed, ranging from Co_2O to CoO_2, some are doubtful, and only three have technical importance. The commercial black oxide is largely Co_3O_4 with some Co_6O_7; the latter resembles the former, and has not been obtained in the pure state. The purification of the commercial Co_3O_4, now obtainable fairly pure, is effected by dissolving the oxide in hydrochloric or sulphuric acid, precipitating the hydrate with bleach and calcining it at 750° C. Above 910° the oxide loses oxygen and passes into CoO, which was obtained in a grey and a yellow-green modification, both non-magnetic. For the reduction to metal the purified greenish-black Co_3O_4 was used; it contained Fe, Ni, S, SiO_2, and sometimes Ca, but at the worst 0·4 % of any of these; in the commercial oxide also used, some of these impurities might exceed 1 % each, and very small amounts of As and P might be present. The reduction was effected by four agents: (*a*) By carbon in an oil-fired Steele-Harvey or in a Hoskins electric resistance furnace, charges of oxide up to 10 lbs. and carbon being intimately mixed (or briquetted with molasses), both materials powdered in crucibles of graphite (lined or unlined) or clay. With anthracite the reduction was not rapid below 1200° C.; in the oil furnace an excess of 10 % of coal was required, not in the electric furnace, on account of the generation of CO. With charcoal and lampblack the reduction was complete at 900°, but an excess of carbon of 20 or 30 % was necessary; the resulting cobalt need not contain more than 0·2 % of C. Briquetting lowered the required temperatures. (*b*) By hydrogen, the charge being placed in an alundum boat in a horizontal tubular electric furnace built up of coaxial carbon rings pressed together. The reduction took place in a few minutes at 500 to 700°, but was not complete until the temperature exceeded 960° ; the resulting Co had to be cooled in a hydrogen atmosphere ; the method is recommended for the production of small amounts of pure metal, free from C. (*c*) By CO, obtained by passing CO_2 through electrically heated charcoal over the oxide in another resistance furnace. The reduction was rapid above 600°, and complete above 900° ; between 880 and 450° the reduced metal decomposed the CO again under deposition of carbon ; cooling in CO was required ; no mention is made of a carbonyl compound. (*d*) By aluminium thermit ; the reduction was simple and rapid, and is recommended therefore, though somewhat expensive ; the Co contained up to 0·1 % of Al ; more Al could be introduced to form alloys of Al-Co.

II. *Physical Properties of the Metal Cobalt.* **H. T. Kalmus** and **C. Harper.** Journ. Engin. Chem. 7. pp. 6–17, Jan., 1915.)—The "pure" metal contained was of 99·9 or 99·7 % Co, the commercial cobalt of 96·5 % and more ; the impurities consisted of Fe, Ni, C (0·06 to 0·87 %), S and P. The polished cobalt looked white like nickel, with a bluish cast. The density of pure Co was 8·79 unannealed, 8·81 annealed, 8·925 swaged. The Brinell hardness of Co cast from just above melting-point and cooled in an iron mould, was 124, considerably higher than that of Fe and Ni under corresponding conditions ; the effect of the carbon of the commercial metal was not sufficient to offset the effect of slight variations in the heat treatment. The melting-point of the pure Co was 1467° in an Arsem electric vacuum furnace (alumina crucibles) assuming the melting-point of Ni to be 1444° ; accepting the value of Burgess and Waltenberg for the latter, 1452°, the authors would find 1478°, exactly like Burgess and Waltenberg. The tensile strength of pure Co (Riehle machine) was 34,000 lbs./sq. in. ; it was slightly raised by annealing, much raised by rolling (up to 100,000 lbs. in swaged wire) ; the yield-point was very close to the breaking load ; the tensile strength of commercial metal was much higher, 61,000 lbs. (effect of carbon ?), and the reduction in area and elongation were increased by 20 % by the impurities. The compressive strength of pure Co was 122,000 lbs./sq. in. ; this was slightly lowered by annealing ; that also applied to commercial cobalt. Most of these strength values are considerably higher than those of iron and nickel. Pure cobalt may readily be machined on the lathe, although it is somewhat brittle ; the addition of carbon renders it less brittle. Commercial cobalt could be swaged ; the pure cobalt could not, unless it was first squeezed tightly into an iron mould, heated in it to 1150°, then compressed by chilling the outside of the mould and slowly cooled. The specific electric resistance of swaged wire, 0·08 in. diam., of pure Co was $89{\cdot}64 \times 10^{-7}$ ohm-cm. or 0·7769 ohm per metre-gramme ; annealing *in vacuo* slightly decreased the resistance ; annealing in CO_2 first increased it up to 600° and then decreased it ; this and the strength measurements indicate the presence of occluded gas in the cast metal. Very slight impurities affect its resistance very much. Magnetic tests of Co and alloys are being made. The specific heat of the pure metal was found to be 0·1056 between 15 and 100° C., in agreement with Tilden, who had studied the range −182° to + 200°. H. B.

226. *The Theory of Hardening and the Constitution of Steel.* **E. D. Campbell.** (Iron and Steel Inst., J. 90. pp. 1–10 ; Correspondence, pp. 11–16, 1914. Engineering, 98. pp. 472–473, Oct. 16, 1914.)—The conclusions

of McCance and Carpenter and Edwards [Abs. 1757, 1758 (1914)] with regard to the theory of hardening steels are criticised, a number of weak points in both theories being pointed out. Work on this subject has been in progress at the University of Michigan since 1875, where the following working hypothesis has been gradually evolved as a basis for the experimental work. The chemical constitution of steel is regarded as a study in solubilities, and forms the most important single factor in determining the mechanical properties of the steel. Iron is capable of existing in at least two allotropic forms, α and γ, differing somewhat in mechanical properties but most markedly in solvent and dissociating power, the γ form possessing a much greater solvent power than iron in the α condition. There is no necessity for assuming the existence of a β modification of iron. Just as in the case of isomorphous crystals partial substitution of one by the other produces changes in the physical properties of the substance without altering the crystal form, such elements as Ni and Mn can atomically replace iron in the molecule without changing the crystalline character of the material but giving rise to considerable alterations in the physical properties, especially as regards solvent and magnetic properties. A brief review is then given of the studies which have been made of the solutes or the dissolved carbides existing in steels. Earlier work of the author has shown that in annealed steels, the mean molecular weight of the hydrocarbons evolved on dissolving them in dilute acids decreases as the percentage of carbon increases. This points to the mean molecular weight of the carbides existing in low-carbon steels being lower than that of the carbides existing in high-carbon steels. The mean molecular weight of the carbides in a given steel appears to decrease when the steel is hardened. More recently it has been shown that the carbides of low molecular weight are more readily soluble in iron than those of higher molecular weight; that they have a greater hardening effect but tend to dissociate more readily with rising temperature.

A plea is put forward for regarding the iron carbides as substitution products of the hydrocarbons. There is no reason for assuming that carbon will lose its most characteristic property of linking into chains because it is combined with iron, and this simple assumption offers a reasonable explanation for a number of observed facts for which there is no satisfactory solution on the basis of the other theories. For example, the work of McCance shows that the specific volume of steels increases in a much greater proportion than the percentage of carbon. This is reasonably accounted for by assuming that several carbides can exist; since it has been shown above that as the percentage of carbon increases, the molecular weight of the carbide decreases, the number of molecules present per unit volume increases, and, as a result, the osmotic pressure at a given temperature increases more rapidly than the amount of carbon; whereas on the assumption of the existence of the single carbide Fe_3C, the increase in specific should be a linear function of the carbon present. The author suggests that austenite is a solid solution in which the carbides have undergone complete ionic dissociation. F. C. A. H. L.

227. *Electrolytic Endosmose.* **H. G. Byers** and **C. H. Walter.** (Am. Chem. Soc., J. 36. pp. 2284–2291, Nov., 1914.)—The authors give first an historical summary of this subject. Their own experiments, carried out on solutions of different concentrations of a number of electrolytes in cells having three or six compartments, lead to the following results:—Endosmose is capable of producing flow of electrolytes in the direction of the current, in the opposite direction and in both directions at once. In certain cases the flow of the electrolyte is away from both electrodes, and also may be more rapid away from one than to the other; in either instance the content of the middle compartment of a tripartite cell is increased. In the cell with six compartments, the change in volume is not confined to the anode and kathode compartments, but varies in the other compartments in an apparently erratic manner. The quantity of water transported is clearly affected by the dilution of the electrolyte. When clay membranes are used, the endosmose is complicated by stenolysis. It is not clear how electrical charges on the plates, induced by varying degrees of ion absorption or otherwise, can account for the passage of water through the plates. T. H. P.

228. *Current Potentials of Solutions of Electrolytes.* **H. R. Kruyt.** (K. Akad. Amsterdam, Proc. 17. pp. 615–622, Nov. 7, 1914.)—The author has determined the e.m.f. which is produced when solutions of electrolytes flow through a capillary tube under a constant pressure. The solution under investigation was passed from one Woulff bottle to another through the capillary, and in each bottle dipped a Ag-AgCl electrode. Measurements were made with solutions of KCl, $BaCl_2$, and $AlCl_3$, the concentrations varying from 0–1000, 10–40,000 and 0–500 millimols per litre respectively. For a given solution the ratio of e.m.f. to pressure (E/P) remains constant. With increase in concentration of the solution the ratio E/P diminishes, becoming very small at the above-mentioned maximal concentrations. The greater the valency of the kathion the more is the charge on the capillary reduced, when equal concentrations are compared. In the case of $AlCl_3$, a 0·8-millimol. solution lowers the e.m.f. from 850 millivolts (for pure water) to zero, and for higher concentrations the sign of the charge is reversed, the charge first increasing with the concentration and then diminishing. The results are in harmony with the theory which postulates an electric double layer in the capillary, OH′ ion being adsorbed more strongly by the glass than H· ion; from the solutions the kathions are more readily adsorbed than the anions and so the e.m.f. is diminished. [See Abs. 1470 and 1965 (1909).] T. S. P.

229. *Overvoltage.* **E. Newbery.** (Chem. Soc. J., Trans. 105. pp. 2419–2435, Oct., 1914.)—The anodic and kathodic overvoltages in solutions of 10 % sulphuric acid, using electrodes of lead, platinum, mercury, copper and zinc, have been determined at varying current densities. The influence of time on the overvoltage was also investigated, as also the effect of the presence of colloids (dextrin, gum arabic, and gelatin), the concentration of which varied from 0·02 to 4·5 %. In the case of zinc electrodes, sufficient zinc sulphate was added to the electrolyte to cause zinc to be deposited instead of hydrogen. In the absence of colloids the general conclusions arrived at are as follows:—When hydrogen is being liberated with a low current density the overvoltage increases with time, apparently without limit in the case of Pt, and to a high but variable limit in the case of Hg. With a high current-density the overvoltage of Pb, Pt and Hg increases to a maximum, the position of which depends on the current density, and then falls slowly; the time taken to reach the maximum varies with the metal, and is diminished in all cases by increase in the current density. When a metal is being deposited the time effect is almost negligible.

The experiments with colloids showed that a penetration of the colloid into the metal takes place, a permanent change in the physical nature of the metal surface resulting. The presence of a colloid in all cases raises the hydrogen overvoltage, the overvoltage during the deposition of a metal being affected to a much smaller degree. The change in the physical nature of the metal surface affects the future behaviour of the metal when used afterwards in a colloid-free electrolyte. No appreciable influence is exerted on the overvoltage by the application of a pressure of 100 atmos.

Measurements of the ionisation of the gas liberated during electrolysis gave the following results for the influence of various factors :—Changes in the *current density* affect the degree of ionisation very little. The effect of *temperature* is considerable, and varies with the metal used; rise in temperature increases the ionisation. Ionisation decreases with the *time*, except in the case of mercury, where it increases. A very small quantity of a *colloid* (0·1 % of gum arabic) lowers the degree of ionisation; the effect of other impurities was variable. The amount of ionisation also varied with the electrode used. In every case tried, where an increase in the quantity or degree of ionisation of electrolytic gas is produced, a corresponding fall of overvoltage is observed, and *vice-versa*. The results obtained indicate that the overvoltage of a metal is determined by three factors : (1) Supersaturation of the electrodes with gas in the molecular condition, the accumulation of this being brought about through the permeability of the metal to ions, and the inability of the free gas to escape except by solution or breaking the metal surface. (2) Deficiency or excess of intermediate metastable products which are formed in the transition from the ionic to the molecular state; this intermediate product is probably the non-hydrated ion. (3) The inductive action of the escaping ionised bubbles on the electrode. For example, hydrogen liberated in an acid solution is positively charged and acts inductively upon the electrode, greatly lowering the overvoltage at high current-densities. In certain cases this factor is sufficiently powerful to reduce the measured overvoltage of a metal to a negative quantity. T. S. P.

230. *Use of Hydrofluoric Acid in the Separation of Copper and Lead from Tin and Antimony by means of the Electric Current.* **LeR. W. McCay.** (Am. Chem. Soc., J. 36. pp. 2375–2381, Nov., 1914.)—Tin and antimony and their alloys are readily soluble to a clear solution in dilute nitric acid containing hydrofluoric acid, the best solvent being 25–50 cm.^{3} of dilute nitric acid (1 : 4) to which 5 cm.^{3} of 48 % hydrofluoric acid have been added. The solutions are made in Pt vessels. All the Sn, but only a part of the Sb, is converted into the higher state of oxidation; the oxidation of the Sb is completed by adding, drop by drop, with constant stirring, a saturated solution of potassium dichromate until the pure green colour of the warm solution takes on a slight, yellowish-green tint. The chromic salt and the small excess of chromic acid have no influence on the separation of copper and lead from Sn and Sb, or on their subsequent separation. From such solutions copper and lead can be deposited quantitatively, the copper at the kathode and the lead as dioxide at the anode. Details are given of the separation of Cu from Sn, Cu from Sb, Pb from Sn, Pb from Sb, and Pb from both Sn and Sb; the estimation of both copper and lead in a white metal is also described. From a dilute nitrohydrofluoric acid solution copper can also be separated from tungsten, and mercury and silver from Sn and Sb. T. S. P.

231. *Flame Reactions.* III. **W. D. Bancroft** and **H. B. Weiser.** (Journ. Phys. Chem. 18. pp. 762–781, Dec., 1914.)—The authors find that reactions may be brought about electrolytically under such conditions that light is emitted, and have investigated more particularly the luminescence and the conditions for obtaining it, accompanying the electrolysis of solutions of chlorides, bromides, iodides, and sulphates with a mercury anode; anodes of tin, copper, cadmium, silver, and lead were also employed. Whenever luminescence was obtained it was preceded by the formation of a firm, coherent film on the anode, and the seat of the luminescence lies in the reaction zone beneath this film, which must be a bad conductor. The heat generated by the resistance causes a local rise in temperature at the surface of the metal, the reaction emitting the light being the union of the nascent anion with the heated, and presumably volatilised, metal to form the solid salt. No luminescence was observed if the metal dissolved on corrosion instead of forming the solid salt. Generally the solubility is least and the stability greatest in the cold, so that the luminescence should be greater in the cold; this is markedly the case with a mercury anode in potassium bromide solution. In the many instances where the heated metal will burn brightly in oxygen or one of the halogens the colour of the flame is strikingly similar to that obtained electrolytically. With a stationary anode the luminescence is usually only a flash, since the film masks the luminescence and also cuts down the current so that the reaction velocity is very low. In most cases the luminescence may be made continuous by rotating the anode rapidly and brushing it with a tooth-brush in order to prevent the film from becoming too thick. [See Abs. 1005, 1467 (1914).] T. H. P.

232. *Electrolytic Determination of Nickel.* **W. J. Marsh.** (Journ. Phys. Chem. 18. pp. 705–716, Dec., 1914.)—Electro-analysis according to Classen's oxalate method is applicable to the estimation of tin, but not to that of Ni or Co. In the case of Ni the use of various "addition agents" proved ineffective: small amounts of urea merely gave a somewhat more rapid deposition of the metal, while the accompanying carbon deposition was unaffected. Decreasing the size of the anode augmented the tendency of the Ni to deposit as peroxide. The following method gave reliable results: 200 cm.^{3} of a solution containing about 0·2 gm. of nickel (as $NiSO_4, (NH_4)_2SO_4, 6H_2O$), 15–20 cm.^{3} of ammonia (sp. gr. 0·96) and 5 gm. of ammonium sulphate, no nitric acid, nitrates or chlorides being present, were electrolysed in a 350-cm.^{3} beaker, using a Pt-gauze flag anode (52 mesh and 6 × 4·5 cm.) and a rotating (550–650 revs. per min.) pure copper gauze kathode (50 mesh and 5 cm. high × 3 cm. diam.). With a current of 0·8 amp. at 3·5 volts the time required at room temperature was 25 mins. The copper-wire gauze kathode was also used successfully in the estimation of Cu, Sn, Co, Cd, Bi, Ag, and Zn, and for Pb and Mn by deposition as peroxides on a Pt-wire gauze anode. Stiff, twisted copper wire was used for the stems, and the gauze was riveted with small copper tacks. Such kathodes may be used repeatedly if dipped into nitric acid (1:1) for a few minutes after each estimation. [See Abs. 290 (1910).] T. S. P.